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# Multi-input Single Stage Three Port DC-AC Converters in Renewable Energy Applications – An Overview

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**Abstract** Nowadays power electronics three port DC-AC inverters are being broadly used in different devices, such as solar smart mini and microgrid energy systems, standalone smart home energy system. In the recent past, reliability, control technique, efficiency, modularity, and cost-effectiveness are the vital issue for these converters. Many triple port DC-AC inverters have been developed demonstrating by three stages and two stages multiple input single output and single stage multiple input single output inverters. But multiple stages of three port DC-AC inverter is costly and lower efficiency for using a higher number of components at different stages. Research is continued about single stage DC-AC topology to reduce the price and decrease the use of some elements. The study of different multi-input single stage three port DC-AC converter topologies with their control method and application area has been stated in this paper. In this research represents some of the update configurations in the improvement of multi-input and single output triple port DC-AC inverters.

***Keywords:*** *DC-AC Converter, single stage, renewable energy, multi-input*

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## 1. Introduction

At present green power resources such as solar photovoltaic (PV) and wind production scheme are being replaced by traditional generation units for electricity generation, because of the world energy crisis and environmental complication induced by traditional energy sources [1].

Leading power electronic protocols are required to deploy and establish green energy resources. After all, the discontinuous behaviour of the green energy resources and uncertainty of the requirement of demand make another problem, due to various utilization of the particular renewable energy resources [2]. To mitigate the challenges of the periodic behaviour of the green energy and the fluctuation of the requirement of load, power electronic inverters with energy storehouse protocols are normally used to invert the produced energy of the solar PV to fulfil the requirement of demand [3]. Now-a-days Power electronic inverters are being broadly used in different devices such as solar smart mini and microgrid energy systems, standalone smart home energy system, electric vehicles and energy storage system either at output DC or AC. Double stage or single stage contact are being widely used to invert the generated energy from green energy resource to DC or AC.

Conventionally, the double stage topologies with two traditional DC-DC converters and a DC-AC converter as presented in Figure 1(a) and (b) are big sizes, much costs and less efficient because of the usage of three converters. Along the progress of triple port inverters, an innovative dual step structure is proposed by using two converters as shown in Figure 1 (c). The single stage topology is needed for better performance and a less cost in comparison to the double stage configuration. As a result, a three ports single stage DC–AC inverter can be developed by using the concept of single stage DC–DC triple port converter, this contains a DC incoming port for combining the resource of green energy, for the contact of an energy storehouse scheme other DC gate used and AC output gate used to supply the other devices or the grid straight. Figure 2 present the combine of the green energy and energy storehouse inverters into the single inverter along dual DC incoming port and single AC output.

In many kinds of literature, advantages and reviews of single stage DC-DC topologies with comparing the count of elements and performances has been stated [4]. In recent years there are many single stages DC-AC converter recommended by the different research group. But there is no literature into a single paper by accumulated of the recommended one step multiple incoming DC-AC converters which would be helped to compare their features and to know their application area. So, this research paper presents a concise survey of triple gate single topology DC– AC inverters recommended by

various scientist in past few years. There are two types of single topology DC-AC inverter such as the non-isolated and isolated inverter. This review paper can be the example for them, so that they can select the appropriate configuration to gain the exact specification in renewable energy application.

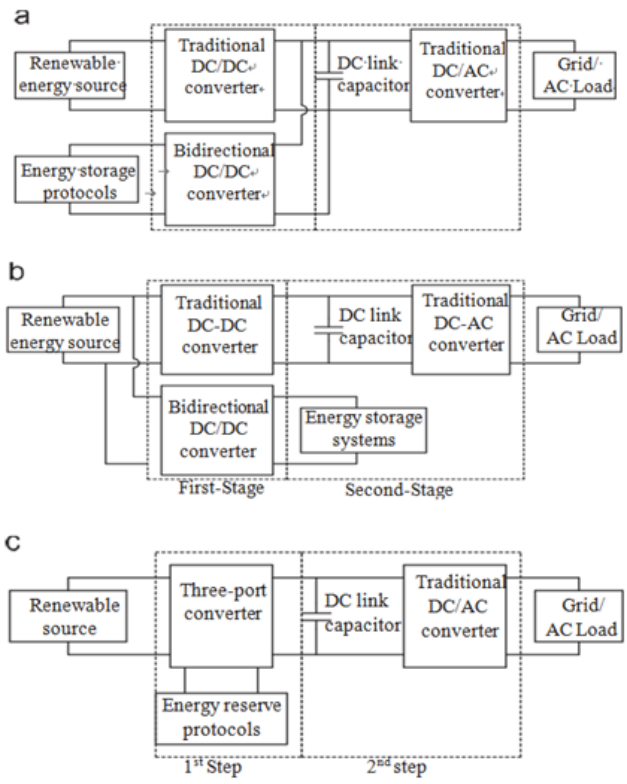


**Figure 1.** Block diagram of dual-step configuration

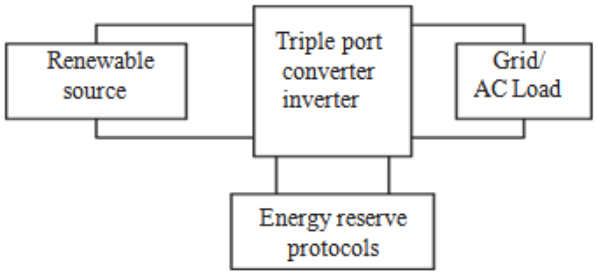


**Figure 2.** Block diagram of one-step configuration

## 2. Non-isolated triple port dc–ac inverters

A lot of non-isolated triple gate DC–AC inverters have been.

Proposed in various article along diverse regulation and feature. Using only one inductor resulting in a compact shape and with the increment of the power expansion, at the same time, rest of them using dual or more inductors. The gain of those inverters is limited due to use of conventional buck, boost, and buck- boost converters. To overcome those shortcomings, few triple gate DC–AC inverters used to increment of potential gain by coupled inductors.

A conventional non-isolated converter consists of two inductors, which is shown in Figure 1. In this recommended Z-source converter has dual unique control configuration [5]. The quantity of power that must be loaded or unloaded, measures by the protocol administrator, again the quantity of energy that must be provided through FC is measured then directed toward the FC administrator to control the amount of change of fuel flow.

n advanced space vector modulation (SVM) scheme has been proposed for diode clamped three stage inverters switch changeable dc link potential. Further, maximum regulation ability above little vector choice also possible in this proposed SVM scheme [6], which is shown in Figure 4. A pulse width modulation founded SOC adjustable regulator is recommended to regulate this little vector configuration.

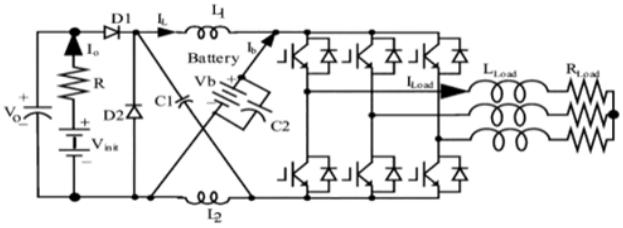


**Figure 3.**Experimental setup.[5]

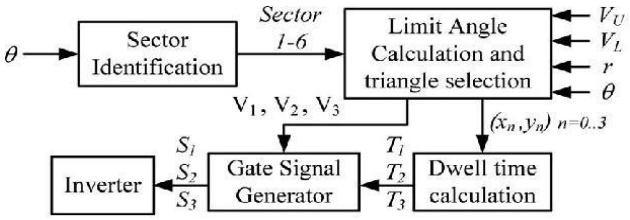


**Figure 4.** Block layout of the recommended SVM configuration [6].

The recommended Quasi-Z-Source Inverter (QZSI) and power storehouse system is shown in Figure 5. This research paper shows PV technology which is the changed version of the QZSI topology. A power reserve module was joined to it without any additional chip, only particular input impedance network is used [7]. To obtain more efficient control, QZSI uses two independent control variables. Which also able to running along an energy storage system.

An innovative paper for a triple step neutral point clamped (NPC) voltage source inverter has been presented shown in Figure 6(a) [8]. The proposed topology can combine with both green power and battery storehouse device which contain in the dc side of that converter. Figure 6(b) present the updated topology where double batteries are joined with dual capacitors over double relays.

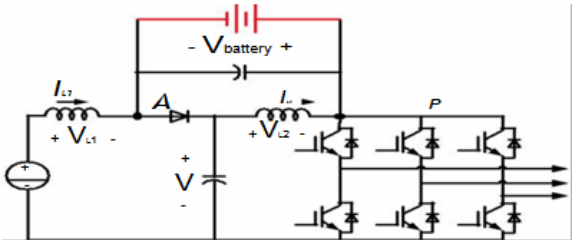


**Figure 5.** QZSI topology with Energy Storage system [7]

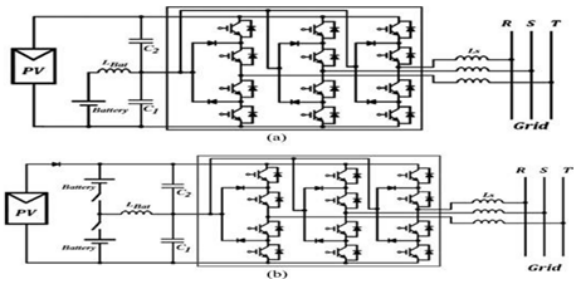


**Figure 6.** Recommended topology for combine solar PV and battery storage:(a)traditional system; (b) updated system [8].

Another energy storage QZSI has been recommended to reduce the deficiency of the current resolutions in solar PV energy device [9]. Here capacitor C1 connected with the battery in parallel, which towards to a new configuration show in Figure 7. Here the DSP-based controller used to gain the recommended control methods.

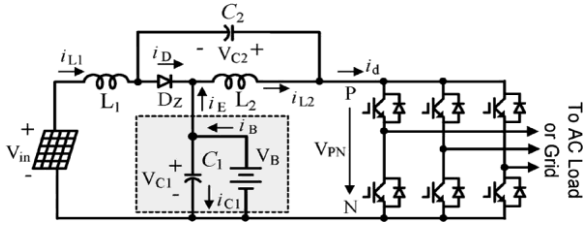


**Figure 7.** QZSI topology for solar PV power production [9]

The primary topology of the recommended dual input inverter is presented in Figure 8. The proposed configuration contains three switch legs, which usually applied as a double outgoing converter and ac to ac converter. The recommended inverter is capable to operate buck, boost and AC alteration [10]. A simple dual-loop regulator configuration is used to regulate the output ac voltage. Whose inner loops are the current controller and outside loops are the voltage regulators.

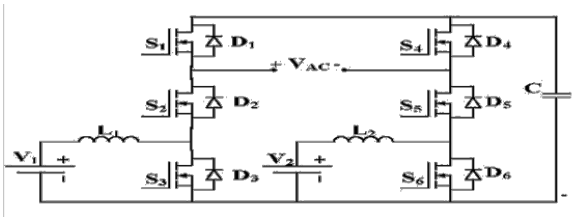


**Figure 8.** Double Input Single Output DC-DC-AC inverter [10]

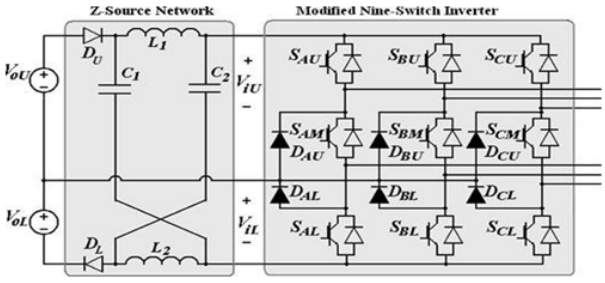


**Figure 9.** Double input and double output z-source converter [11]

A novel z-source three level NPC inverter is presented in Figure 9 [11]. The inverter is consisting of an altered nine switch converter along with a double input double output Z-source configuration, which also contains extra six diodes. Here the z- source configuration system is used as front side boost inverter of a tradition which is suitable for the fuel cell, and solar PV and wind turbine modules.

A boost inverter based bidirectional single stage switching configuration is presented in Figure 10 [12]. This scheme internally connects with different sources externally the necessity of extra switches which combines buck boost inverter with multi for perfect dc output. Various input dc-dc converters make a circuit simple and decrease price efficiently. This proposed converter can be used for the hybrid system, which consists of solar PV, wind energy and fuel cells.

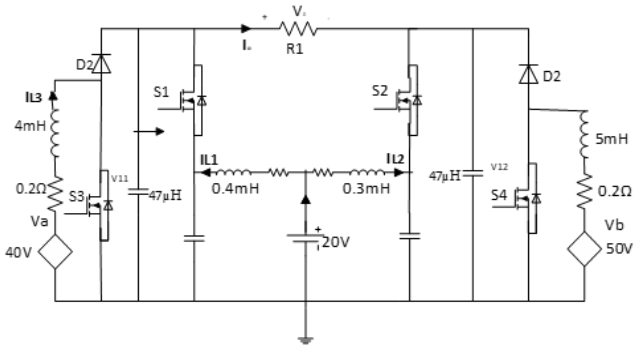


**Figure 10.** Single-stage multiple input boost inverter [12].

The DBI-based Double Input-Double Buck Inverter (DI-DBI) DC/AC power configuration is proposed in Figure 11 [13]. The advantages of this inverter are improving the conversion efficiency by decreasing the active conversion steps. The DI- DBI is executed by replacing the one input Buck switching bridges in the conventional dual-buck inverter along dual-input vibrating source cells.

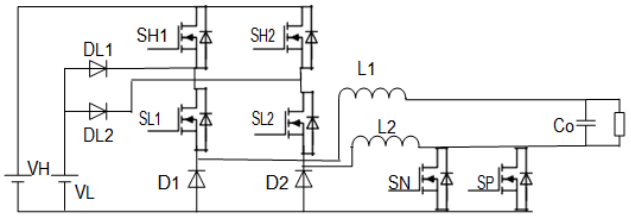


**Figure 11.**the proposed dual-input DB6 inverter [13].

## 3. Isolated triple-port dc–ac inverters

In term of isolated triple gate DC–AC inverters, discharge of the energy through any two ports of the triple gates over a various winding higher frequency transformer. As results this category of inverters has better propulsive isolation. The conventional full bridge inverters or half bridge inverters or the combo of them are the core basis of isolated converters for energy transformation.

Phase-modulated higher frequency isolated dc-ac inverter as the grid alliance in an allocated production configuration shown in Figure 12. The recommended dc-ac inverter also used in combining energy origins straight to the service line when the isolation is a mandatory [14]. For the action of the error and generate exact phase shift a PI controller is recommended.

A multiple input converter scheme is recommended to reduce the energy protocol design and decrease the price of hybrid PV energy or wind energy system [15]. Figure 13 shows triple port simplified half-bridge technology and the developing circuit.

This research focuses into multiple input green power resources for DC-AC converter (MII) configuration. Figure 14 present the circuit of the multiple input DC-AC converter. The recommended MII contains both the DC-DC boost inverter and a one phase full bridge DC-AC converter. The generated potential, (Vout) of converter directly entered to the SPWM control system, which received by compensator as feedback regulator [16].

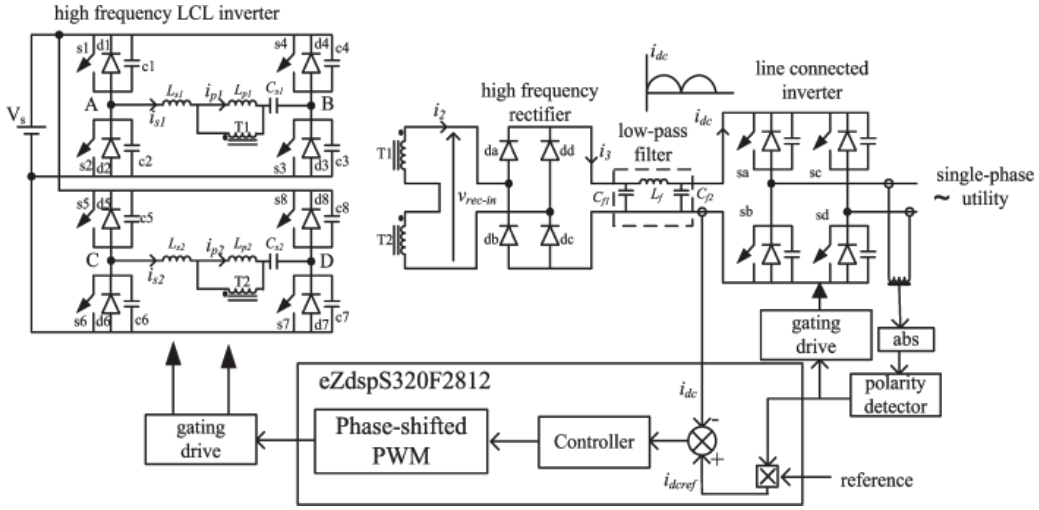


**Figure 12.** Block diagram of HF unique double bridge LCL resonant inverter to combine a dc supply along one phase line. [14]

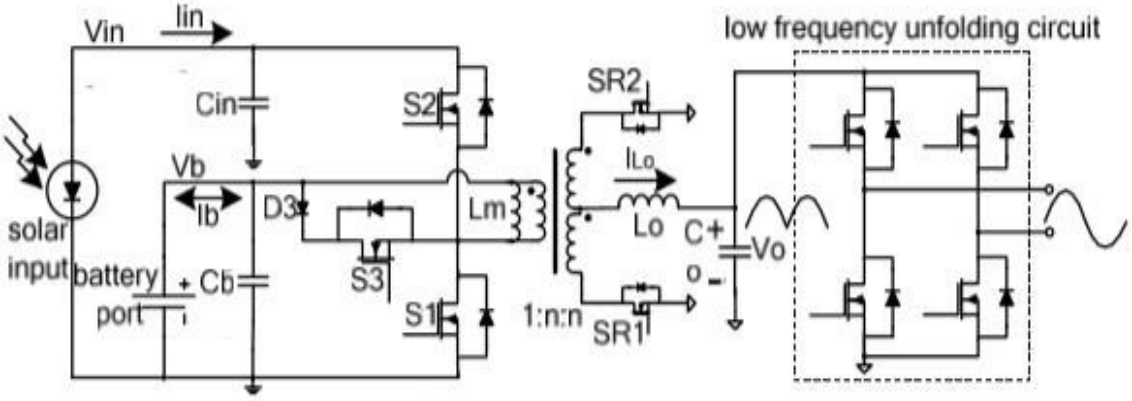


**Figure 13**.Triple gate simplified half-bridge configuration with the developing circuit [15]

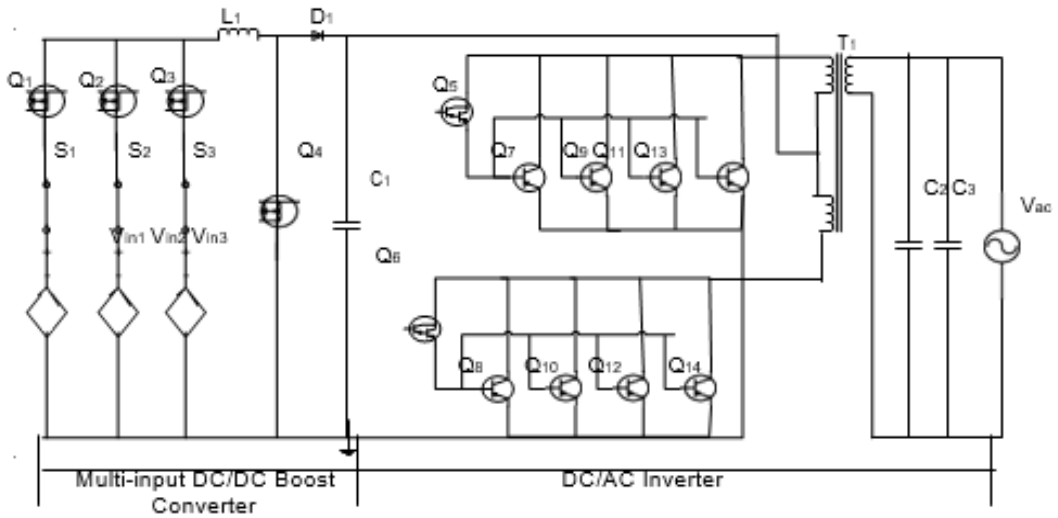


**Figure 14.** Schematic diagram of MII [16]

**Table 1. Comparison of Multi-input single stage three port DC- AC converters (NA: Not Available)**

| Type converter | No. of semiconductors | No. of inductors | Reported capacity | Features | Ref. |
|---|---|---|---|---|---|
| Non-isolated | 6 Switches, 2 diodes | 2 | 10 kW | Less complex; | [5] |
| | | | | Much cost efficient with compared to a dc–dc boost converter; | |
| | | | | Higher accuracy; | |
| | | | | There is no necessity of any dc–dc converters. Z-source converter contain both independent control freedoms; | |
| | | | | With third harmonic injection constant boost control is used; | |
| | 12 Switches, 6 diodes | 3 | NA | Higher performance; | [6] |
| | | | | Smaller in size and enhanced longevity; | |
| | | | | Supplementary dc–dc converters are not required; | |
| | | | | Smoothen energy oscillations is actively managed due to satisfactory volume of energy; | |
| | 6 Switches, 1 diode | 2 | 2.2 kW | Good Output voltage regulation; | [7] |
| | | | | At the same time load demand and storage supplying by solar PV; | |
| | | | | Due to energy storehouse system converter is capable to perform even the useable PV energy much less than the demand energy; | |
| | | | | Strongly controlled the output voltage with every single current phase variation; | |
| | | | | The storage is capable to supply energy, beyond any change of the regular behaviour of QZSI; | |
| | 12 Switches, 6 diodes | 4 | 300 W | Less cost; | [8] |
| | | | | Better efficiency; | |
| | | | | Increased flexibility; | |
| | | | | To fulfil the power transmission demands, converter is able to perform under unstable dc voltage system; | |
| | | | | AC side current also capable of control in this configuration; | |
| | 6 Switches, 1 diodes | 2 | 3 kW | More effective control. | [9] |
| | | | | Deficiency of the traditional result in solar PV power configuration can overcome; | |
| | | | | The DSP-based controller can be used; | |
| | 6 Switches | 2 | NA | This recommended inverter is capable to operate buck, boost and AC alteration; | [10] |
| | | | | Maximal modulation index is restricted; | |
| | | | | Simultaneously both dc-ac and dc-dc part can perform with lowest limitation; | |
| | | | | Capable to combine dual ac type power sources into the utility grid; | |
| | 9 Switches, 8 diodes | 2 | NA | The voltage progress is higher than the traditional nine-switch converter; | [11] |
| | | | | Simple control strategy; | |
| Isolated | 12 Switches, 4 diodes | 5 | 1 kW | No duty-cycle; | [14] |
| | | | | It has 2 Transformer; | |
| | | | | Traditional stable frequency phase shift control is excluded; | |
| | | | | It has potential for high power device; | |
| | | | | The disadvantage of use parallel inductor, which outcomes is larger size and higher cost; | |
| | 5 Switches, 1 diodes | 2 | 60 W | Higher efficiency; | [15] |
| | | | | Higher reliability; | |
| | | | | Consists 1 centre tapped transformer; | |
| | | | | Due to lower conversion stages, cost become lower; | |
| | | | | Operated at very low frequency | |
| | | | | Low-cost low power standalone PV system | |
| | | | | By simple modification of the conventional half bridge DC-DC inverter three port configuration can be obtained; | |

| Type converter | No. of semiconductors | No. of inductors | Reported capacity | Features | Ref. |
|---|---|---|---|---|---|
| | 14 Switches, 1 diode | 1 | 300 W | High extendibility and flexibility | [16] |
| | | | | Consists 1 centre tapped transformer | |
| | | | | Lower cost | |
| | | | | High efficiency | |
| | | | | Small in size | |
| | | | | Much suitable for hybrid application | |

In this paper table- I shows the comparison of multi-input single stage three port DC-AC converters

# 4. Conclusion

In this paper, a novel overview of the configurations widely used for the triple gate DC–AC inverters has been discussed. This overview indicates those analysis of triple gate DC–AC inverters has earned higher concentration from researchers, who conduct research in the field of combining green power and power storehouse application to overwhelm the periodic behaviour of green power sources. The different control method and different application area, merits and demerits of various configurations are provided here. The triple gate DC–AC inverter topologies are normally preferable to the conventional double step model in terms of performance, energy quantity, shape, and low price inverter. This comparison table of the triple gate DC–AC inverters recommended by various scientists is being prepared for next publication which will give a guideline for the suitable choice of inverters for apply in real devices. Due to stimulate the extensive usage of triple gate DC– AC inverters in combining green energy sources and energy storehouse topologies, prospective scientist requires to be executed to increment of the potential boost and performance of that inverter and to scheme innovative triple gate DC–AC converters with a simple and easy control technique.

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