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MODELLING AND CONTROL OF A NEW THREE INPUTS DC-AC COVERTER FOR HYBRID PV/AC/BATTERY POWER SYSTEM

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ABSTRACT

This converter is interesting for hybridizing alternative energy sources such as photovoltaic (PV) source, AC source, and battery. Supplying the output load, A new three-input dc–ac converter is proposed in this paper. The proposed converter interfaces two unidirectional input power ports and a bidirectional port for a storage element in a unified structure. charging or discharging the battery can be made by the PV and the AC power sources individually or simultaneously. The proposed structure utilizes only four power switches that are independently controlled with four different duty ratios. Utilizing these duty ratios, tracking the maximum power of the PV source, setting the AC power, controlling the battery power, and regulating the output voltage are provided. Depending on utilization state of the battery, three different power operation modes are defined for the converter. In order to design the converter control system, small-signal model is obtained in each operation mode.

Key words —Decoupling method, photovoltaic(PV)/battery hybrid power system, small-signal modeling, state-space averaging, three-input dc–ac converter.

1. INTRODUCTION

The importance of renewable energy sources is recognized by both the general public and the power industries. Some researchers believe the concern for environmental damage is now an even greater priority than the need to preserve the finite natural resources for future generations. Grid/Load-connected PV systems, when located at the point of use have potential benefits suchasreductionin, Transmissionpowerlosses,Conventionalgenerationcapacity requirement, CO2 emissions and fuel costs.

PHOTOVOLTAIC (PV) inverters become more and more widespread within both private and commercial circles. These grid/load-connected inverters convert the available direct current supplied by the PV panels and feed it into the utility grid/load. There are two main topology groups used in the case of grid/load-connected PV systems, namely, with and without galvanic isolation. Galvanic isolation can be on the dc side in the form of a high-frequency dc–dc transformer or on the grid/load side in the form of a big bulky ac transformer. Both of these solutions offer the safety and advantage of galvanic isolation, but the efficiency of the whole system is decreased due to power Losses in these extra components. An improvement in inverter efficiency and a reduction in cost have been achieved by omitting the 50 Hz power transformer (transformer less) and by optimizing the Inverter current control strategies.

The inverter described in this project is specifically for grid/Load-connected PV Systems, it can be used for other traditional applications such as in uninterruptible Power supplies (UPS), motor controls and voltage regulation systems.

Multi-input DC–AC converters are used to combine
different types of energy sources to obtain a regulated DC or AC voltages [1-3].illustrates the power circuit of the proposed multi-input DC-AC converter. In the proposed topology, DG systems with DC output like PV and FC, and ESSs like batteries can be connected to the input ports. The converter is composed of half-bridge converters, a cycloconverter and HFIL transformer. At the input side, each input port contains a boost half-bridge inverter and a DC voltage source. The boost half-bridge inverters provide bidirectional power flow as well as increase the input voltage level. At least, one

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of the DC voltage sources (e.g., second port) should have an ESS to provide energy management in the proposed converter. The HFIL transformer has three windings. The DC capacitors (i.e., *C1*and *C2*) provide a DC link and their voltage remains constant in all operation conditions, as discussed in the next section. Thus, the input ports can have different input voltages and operate independently. So an input port can be added or omitted from the system.

The output port consists of a cycloconverter to provide AC voltage [4-6]. The other features of the proposed converter are given, as follows:

The main input port (e.g., first port) works with a dutycycle equal to 50%, but the duty cycle of the other port is dependent upon the required current, It is possible to draw power from all the input ports at the same time, The gate control signals between each input port are shifted 180 to achieve minimum current ripple for the DC link and small size capacitors.

2. BASIC CONCEPT OF RENEWABLE SOURCES

(i) Cell

A cell is a source of e.m.f in which chemical energy is converted into electrical energy. A cell essentially consists of two metal plate of different materials immersed in a suitable solution. The plates are called electrodes and the solution is called electrolyte. The magnitude of e.m.f of cell depends upon (1) the nature of material of electrodes used and (2) the nature of electrolyte. Using various metals and methods of construction, a large variety of cells has been developed.

(ii) Battery charging circuit

A dc source of suitable magnitude is connected in series with a resonant R, ammeter and the battery to be charged. Ensure that polarity is correct the charging current is adjusted to the required value with the help of rheostat. As the charging process proceeds, the terminal voltage of the battery raises but the charging current constant by adjusting the rheostat. The terminal voltage of the battery and specific gravity of electrolyte reaches the value1.28 and there is enough gassing at the plates, the battery is fully charged.

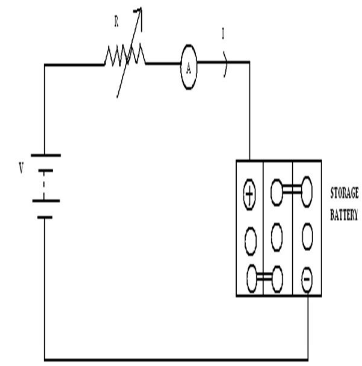

Figure 1. Battery charging circuit

Nowadays photovoltaic (PV) energy appears quite attractive for electricity generation because of its noiseless, pollution-free, scale flexibility, and little maintenance. Because of the PV power generation dependence on sun irradiation level, ambient temperature, and unpredictable shadows, a PV-based power system should be supplemented by other alternative energy sources to ensure a reliable power supply. Battery cells are emerging as a promising supplementary power sources due to their merits of cleanness, high efficiency, and high reliability. Because of long startup period and slow dynamic response weak points of AC, mismatch power between the load and the AC must be managed by an energy storage system. Batteries are usually taken as storage mechanisms for smoothing output power, improving startup transitions and dynamic characteristics, and enhancing the peak power capacity.

3. MULTI-INPUT DC-AC CONVERTER

In this paper, a multi-input port bidirectional direct DC-ACconverter is proposed which consists of High-FrequencyIsolating Link (HFIL) transformer and half bridgeconverters at input ports and a cycloconverter at thesecondary side of HFIL transformer. The input voltage isboosted and the result is a reduction of transformer turns.The existence of a boost inductor reduces the ripple of thecurrent in the input port and provides suitable performanceto meet the desires of applications such as PV and FCsystems.The proposed converter needmultiwindingtransformer for inputs. As a result, it has low partsnumber. Therefore, the converter cost, size and volume canbe reduced and its reduced conversion steps result in higherefficiency. The designed controller is based on Phase Shift(PS)

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control technique to obtain the desired output voltage.The converter is analyzed step by step to show the principleof the converter energy management based on the duty cyclevariation. The analysis of the proposed converter to managepower flow under different operation conditions has beenstudied and simulation results have been used to confirm the theoretical analysis.

(i) Proposed block diagram

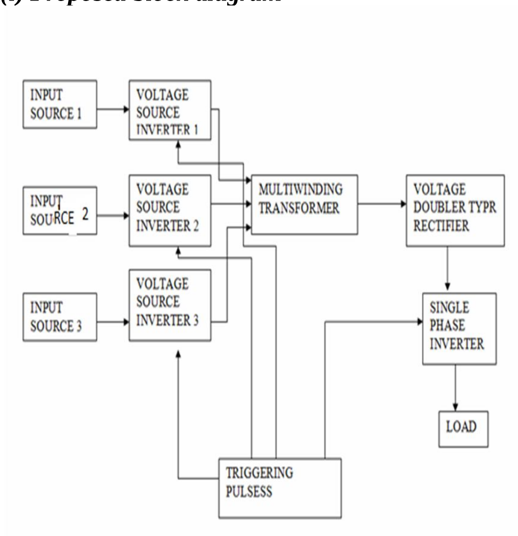

Figure 2. Proposed block diagram

Multiwinding transformer used in this projectAt the input side,each input port contains a boost half-bridge inverter and DC voltage source. The boost half-bridge inverters providebidirectional power flow as well as increase the inputvoltage level. At least, one of the DC voltage sources should have an ESS to provide energymanagement in the proposed converter. The multiwindingtransformer has three windings. The DC capacitors provide a DC link and their voltage remainsconstant in all operation conditions, as discussed in the nextsection. Thus, the input ports can have different inputvoltages and operate independently. So an input port can beadded or omitted from the system. The output port consistsof a cycloconverter to provide AC voltage.

The otherfeatures of the proposed converter are given, as follows: The main input port works with a dutycycle equal to 50%, but the duty cycle of the other portis dependent upon the required current. It is possible to draw power from all the input ports atthe same time.The gate control signals between each input port areshifted 180 to achieve minimum current ripple for the DClink and small size capacitors. The voltage of DC capacitors is regulated by the firstinput port. Adding or disconnecting of other ports has noeffect on the voltage of DC capacitors The electric isolation is implemented by a transformer that has three functions in this paper:

- Providing the electrical isolation between input port and output port.
- Stepping up the voltage and
- Reducing the size and volume of the converter.

A voltage doubler, a part of the AC to DC process, helps in increasing the voltage of the system to almost twice the input.The voltage doubler is an integral part of the alternating current rectification process and helps in increasing the voltage of the system. It produces voltage which is almost twice than the input voltage. This means that the voltage generated by the doubler is twice the peak value of the alternative input current.

(ii) Proposed circuit Diagram

In this section as the converter application, it has been utilized to interface a PV source at the first input port, an FC source at the second input port, and a lead–acid battery at the storage port. In this system, the PV and the FC sources are responsible for supplying a residential load and the battery is employed to supply a part of power demand in the PV poor generation and high-load circumstances in addition to improving startup transitions and dynamic characteristic of the FC. Such a hybrid system necessitates an overall control system to provide MPPT for the PV source [35], regulate the output voltage, set the FC in its reference power [36], and consider the state of charge (SOC).

Regulation of the battery These goals of operation will be optimally realized if the proper operation mode is chosen for the converter. Therefore, the proper operation mode should be determined regarding to the maximum available PV power, the maximum deliverable FC power (PmaxFC), the output voltage value, and the battery charging necessity. In this system, an SOC regulation for the battery is considered to keep the battery voltage in allowable minimum and maximum voltages vBatt.Min<vBatt<vBatt.Max[37]. Through this strategy, if the battery\ voltage is less than vBatt.Min, the state of battery charging is required. In this condition, if the summation of the PV and the

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FC powers can manage to supply and charge the load and battery, respectively, at the same time, the battery charging is started. The amount of the battery charging power depends on the battery capacity *CB* , which is usually chosen less than 0.2*CB VB* (refer to lead–acid battery handbooks). Besides, the battery discharge state depends on the PVand FC power generation and load and it can be started when the battery voltage is higher than *v*Batt.Min.

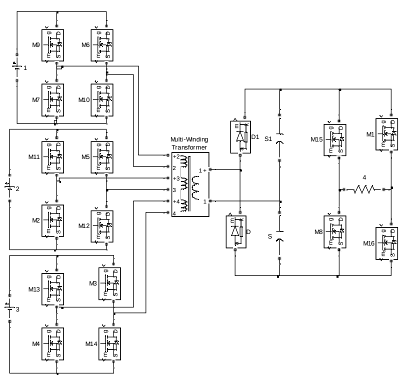

Figure 3.Proposedcircuit diagram

4. MODES OF OPERATION

There are two modes of operation of proposed system they are,

1.Positive mode operation
2.Negative mode operation

(1)Positive mode

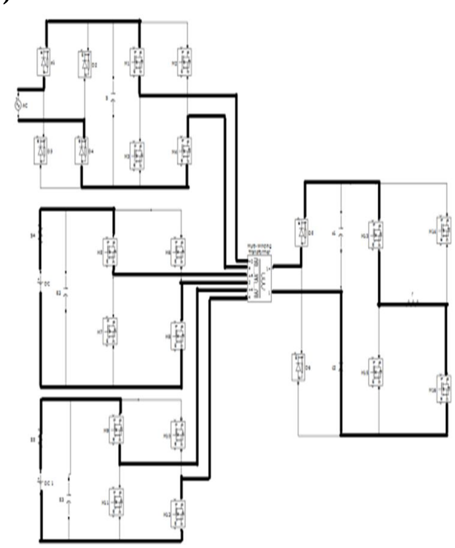

Figure 4.positive mode

(2)Negative mode

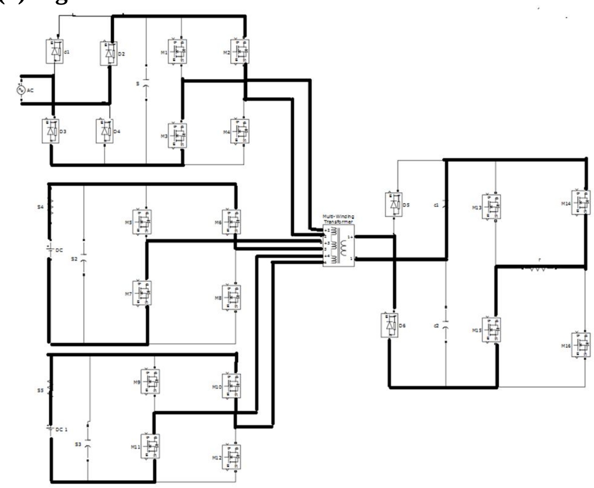

Figure 5. Negative mode

The supply from the DC source is fed to the single phase inverter where, the DC is converted to AC voltage.This AC voltage then passes through the high frequency transformer which boosts the output to twice the input and is fed to the rectifier.
The diode rectifier converts the boosted AC signal to DC and is fed to the DC load. A voltage doubler, a part of the AC to DC process, helps in increasing the voltage of the system to almost twice the input.The voltage doubler is an integral part of the alternating current rectification process and helps in increasing the voltage of the system.

(iii) Advantage Of Proposed System

- Dc to ac converter
- Isolated
- Transformer size reduced (voltage doubler)
- Loading effect is low
- High current gain

5. SIMULATION CIRCUIT AND RESULTS

(i) Conventional circuit Simulation Diagram

The conventional circuit diagram as shown in Fig 6 switches *S*1 and *S*2 are turned ON and inductors *L*1 and *L*2 are charged with voltages across*v*1 and *v*2 and by turning on switch s4 and diode d3 the load has been supplied by the sources v1 and v2.switch*S*1 is turned OFF, while switch *S*2 is still ON . Therefore, inductor *L*1 is discharged withinto the output load and the capacitor through diode *D*1 , while inductor *L*2 is still charged by voltage across *v*2.switches *S*1 , *S*2 , and *S*3 are turned ON, so inductors *L*1 and *L*2 are charged with

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voltages across $v1$ and $v2$ and supplies the load diode D4 and switch S3, switch $S2$ is also turned OFF and inductor $L2$ as like as $L1$ is discharged.

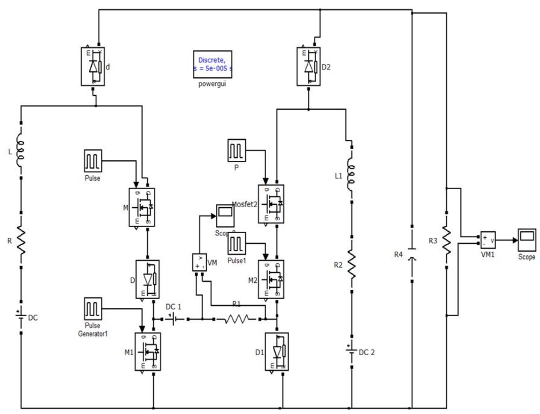
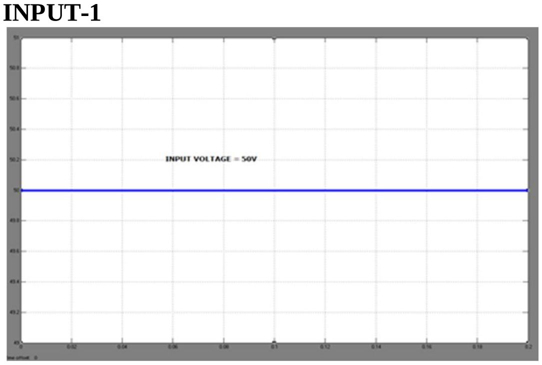


Figure 6.Conventional circuit diagram

(ii) Conventional Circuit Inputs

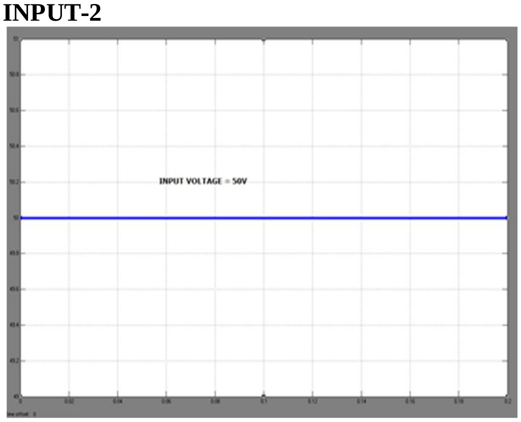
INPUT-1



Time in (sec)

Figure 7.Input voltage1

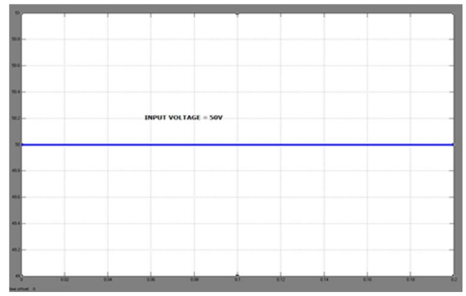
INPUT-2



Time in (sec)

Figure 8.Input voltage2

INPUT 3

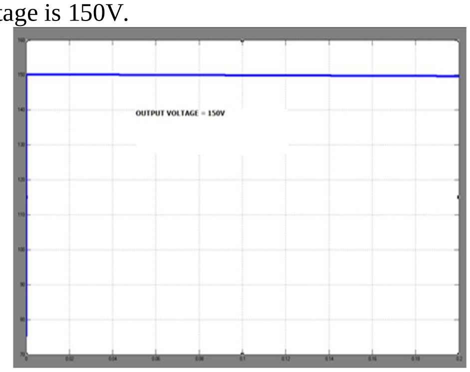


Time in(sec)

Figure 9.Input voltage3

(iii) Conventional Circuit Output

The figure shows the conventional circuit output voltage as shown in figure.Here the output voltage is 150V.



Time in(sec)

Figure10.Conventionals Output wave form

(iv) *Proposed Circuit Simulation Diagram*

Multi-input DC–AC converters are used to combine different types of energy sources to obtain a regulated DC or AC voltages Fig.11 Represents the proposed simulation circuit diagram using Simulink illustrates thepower circuit of the proposed multi-input DC-AC converter. In the proposed topology, DG systems with DC output like PV and FC, and ESSs like batteries can be connected to the input ports. The converteris composed of half-bridge converters, a cycloconverter and HFIL transformer. At the input side, each input port contains a boost half-bridge inverter and a DC voltage source. The boost half-bridge inverters provide bidirectional power flow as well as increase the input voltage level. At least, one of the DC voltage sources (e.g., second port) should have an ESS to provide energy management in the proposed converter.

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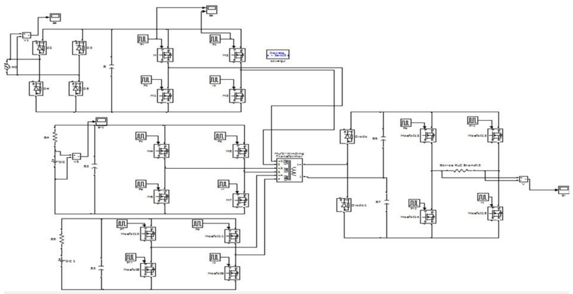


Figure11.proposed circuit diagram

(v) Reposed Circuit Inputs

(a)AC INPUT VOLTAGE

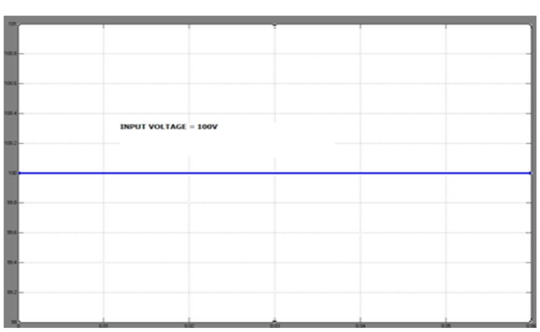
Figure.12 shows the simulated AC input voltage, which is measured across the input side by connecting a voltage measurement with scope.

Time in(sec)

Figure12.input AC voltage

(b)DC INPUT VOLTAGE -1

Figure.13 shows the simulated DC input voltage, which is measured across the input side by connecting a voltage measurement with scope.

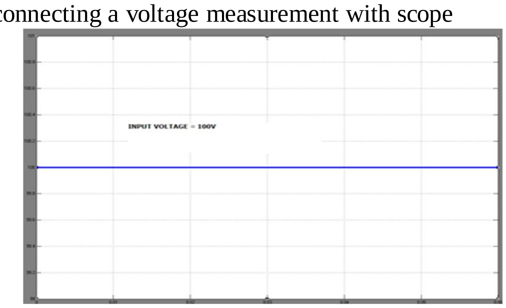


Time in(sec)

Figure13.input DC voltage

(c) DC INPUT VOLTAGE -2

Figure.14 shows the simulated DC input voltage, which is measured across the input side by connecting a voltage measurement with scope



Time in(sec)

Figure14.input DC voltage

Triggering Pulses

The triggering pulses are given to the switching circuits as shown Fig.15

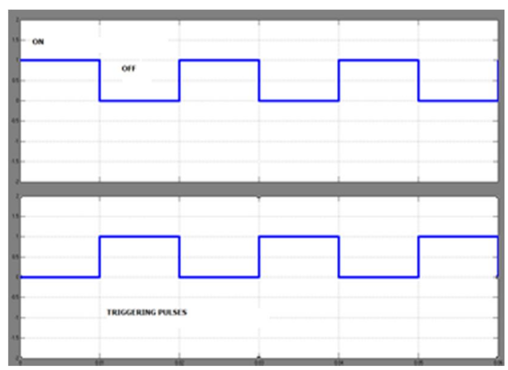
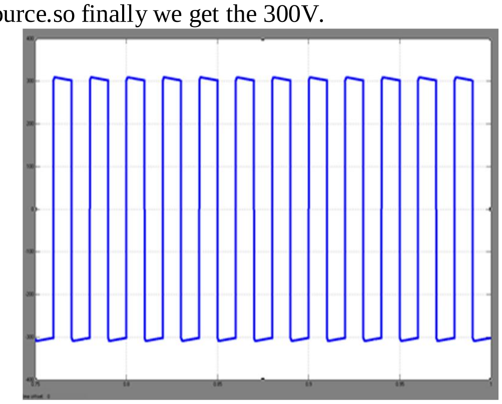


Figure15. Triggering pulses

Output Voltage For 2 Inputs

The output voltage waveform as shown in fig.16.It will represents the failure of any one input source.so finally we get the 300V.



Time in(sec)

Figure 16. Output AC voltage for 2 inputs

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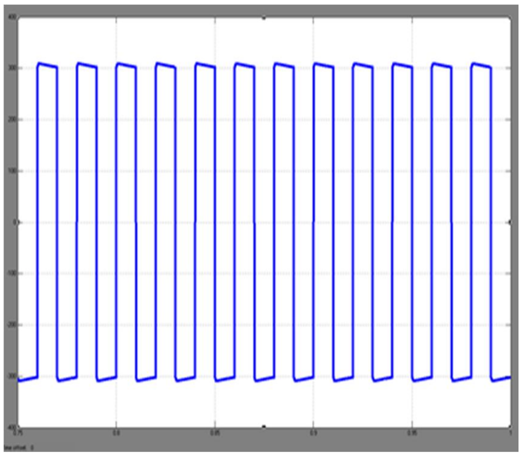
Output Voltage For 3 Inputs

The output voltage waveform as shown in fig.ure17..It will represents the failure of any one input source.so finally we get the 300V.



Time in (sec)

Figure17. Output ac voltage for 3 inputs

6. CONCLUSION

In this paper, a new low cost and small size topology for Multi input DC-AC conversion has been proposed and studied.To improve the dynamic performance, a control strategy hasbeen suggested. This control strategy is simple and based onPS control technique. The proposed converter presents power flow capability and it is very suitable forDG applications. The input converters satisfy the requirements of DGs such as PV and AC systems and Batteryincrease the voltage level at the input of HFIT, as well asdecrease the input current ripple. Also, a reduction in thecount of devices and circuits is obtained. As a result, thecost, size and volume of the converter are reduced. Thereduced number of the conversion steps results in higherpower efficiency for the proposed converter. The simulationresults show the capabilities of the proposed converter.

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