International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com

ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

Volume 10 Issue 12 – December 2022 - Pages 14-28

An Inventive Single-Stage Single-Phase Reconfigurable Inverter Architecture for a Solar-Powered Hybrid AC/DC House

Sameena Jill [1], Md.Khajafarid[2], S.Swapna[3], T.Venugopal[4], Neena Ramesh[5]

1, 2, 3, 4 Assistant Professor, Department of Electrical and Electronics Engineering, Vaagdevi College of Engineering, Warangal, Telangana-506005, India.

5 Associate Professor, Department of Electrical and Electronics Engineering, Vaagdevi College of Engineering, Warangal, Telangana-506005, India.

Abstract **—** This paper proposes a hybrid ac/dc solar powered home's reconfigurable single-phase inverter topology. The primary benefit of this converter is its ability to do dc/dc, dc/ac, and grid tie operation, which lowers loss, costs, and converter size. This inverter has a single-phase, single-stage design. There are both ac and dc appliances in this hybrid ac/dc house. This kind of house isolates DC loads to the DC supply side and the remainder to the AC side, improving the harmonic profile and lowering power loss by eliminating needless multiple steps of power conversion.

The results are verified through hardware implementation using an Arduino Uno controller, and the simulation is carried out in MATLAB/Simulink. An innovative inverter topology installed in a solar-powered house of this kind may serve as the foundation for a smart grid or micro grid that uses less energy in the future.

Index Terms— harmonic reduction, single-phase, single-stage inverter, hybrid ac/dc house, and solar photovoltaic (PV).

I. INTRODUCTION

Globally, renewable energy has grown and evolved in ways never seen in the 20th century [1]. The capacity and production of all renewable technologies have increased significantly, and supportive policies have grown along with them. Of all the renewable energy sources, solar photovoltaic's (PVs) had the fastest growth rate in installed power capacity between 2009 and 2013. Specifically, rooftop solar PV is becoming more and more common in distribution systems because of factors like lower solar panel costs, feed-in tariffs (government policies that encourage the use of renewable energy), modularity, low maintenance requirements, and so on.
Nonetheless, the distribution system's notable stability and dependability issues are a result of the renewable energy source's intermittent nature. The electric supply industry's transformation has led to the current scenario where customers are essential players in the business. To mitigate the uncertainty in solar PV generation, storage options such as battery system and fuelcells, etc., are introduced.
Modern homes are adding more and more nonlinear technology to increase comfort and productivity, but this is also the primary cause of the harmonic current in the distribution feeder. This is a serious problem for electrical engineers and significantly degrades power quality and power losses. The loads seen in modern households are not the same as the loads found in earlier stages. On the other hand, harmonic mitigation and/or its minimization provide significant difficulties for distribution systems. Numerous literary works have been documented to tackle the aforementioned issues in the following ways. The literature [2] discusses the virtual harmonic dampening impedance approach as a means of achieving harmonic mitigation in the distribution system that uses solar inverters. PV-battery storage systems are used in [3] to regulate the distribution system's voltage stability. In order to charge electric vehicles, it is recommended to control a solar-powered grid-connected inverter [4].

The DC micro grid was proposed by Patterson [5], who also outlined its benefits and the difficulties in creating a fully functional DC residential micro grid. In addition, this study examined all structures in 2050 and found that 80% of them had already been constructed. So, rather than creating a brand-new, fully furnished DC home, the emphasis is more on increasing the efficiency of already-existing structures. Vossos et al.'s analysis

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com

ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

Volume 10 Issue 12 – December 2022 - Pages 14-28

[6] looked at how efficient residential buildings are when transformed from traditional ac distribution houses to DC ones. They examined data from 14 states in the USA that distributed DC electricity in houses using voltages of 380 and 24 volts. Replacing AC equipment with DC equipment results in a 33% savings. However, because of their high cost and unavailability of the necessary standards/flexibilities of equipment, it is not viable to replace all of the current home appliances with their DC equivalents. A hybrid ac/dc home grid system is the unique concept put up by Sasidharan et al. [7] to address some of the efficiency concerns and harmonic response problems. As a case study, a solar home is examined. By moving dc loads to the dc supply side, efficiency is increased by 12% and harmonics are reduced by 20%. High DC link voltage, or the line-to-line grid voltage at its peak, is used by conventional grid-connected inverters [8]. To increase the dc voltage and reverse it for this specific need, two stage conversions are necessary. Yet this will result in the system becoming more expensive, larger, and less effective.

Suggested inverter topologies in [9]–[12] are single-phase, single-stage to prevent this.

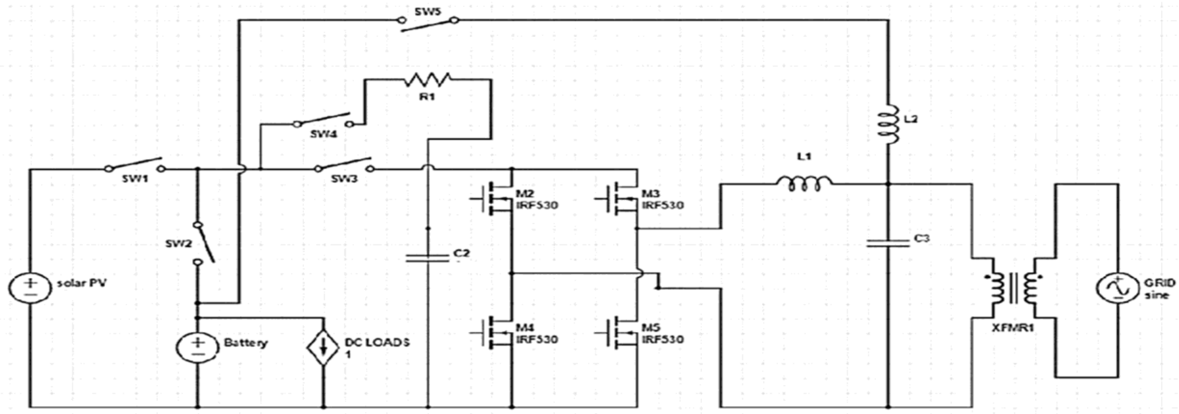

Fig. 1. Schematic of the proposed RSC circuit

Transformer-less inverter have drawn a lot of attention from researchers studying single-phase inverter topologies, as indicated by [13]. Transformer-less inverter are smaller and less expensive since they do not require a transformer; however, they lose their galvanic isolation and are more susceptible to grid disruptions. Due to the intrinsic intermittency of solar PV, battery storage—as defined here—is necessary to provide electricity during periods of low solar radiation. However, the cost and size of the converter will also grow if the battery's power management system requires a separate converter. Therefore, for utility PV systems with battery storage, a three-phase topology of reconfigurable solar inverters is introduced in [14] and [16].

TABLE I

MODES OF OPERATION

Modes of operation	ON switches	Off switches
PV-GRID	SW1 SW3 SW 4	SW2 SW 5
PV-BATTERY-GRID		SW1 SW2 SW3 SW4 SW5
PV- BATTERY	SW1 SW3 SW5	SW2 SW4

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com

ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105

JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

Volume 10 Issue 12 – December 2022 - Pages 14-28

BATTERY-GRID SW2 SW3 SW1 SW4 SW5

This reconfigurable technology is appropriate for wind and solar farm uses. A novel algorithm is used to test this topology, and the outcomes are verified. Every solar-powered home typically has a battery system in place to offer a dependable supply system. When linked to an AC system, these batteries automatically charge; however, when connected to a DC supply side, they require an additional converter to handle the charging process. While Parkhideh and Kim [16] give relatively brief information, single-phase single-stage topology that can supply both ac and dc loads is not well-documented in the literature.

Thus, the primary contribution of this study is to install a reconfigurable solar converter (RSC), a single-phase, single-stage solar converter, in a solar-powered hybrid ac/dc residential building that incorporates energy storage devices. The fundamental idea behind the RSC is to use a single power conversion system to execute multiple operational modes, such as: battery to grid (dc–ac), battery/PV to grid (dc to ac), grid to battery (ac–dc) for solar PV systems with energy storage, and solar PV to grid (inverter operation, dc–ac). A solar-powered hybrid ac/dc home with both ac and dc household loads is used to test this converter. The harmonic contributions that individual appliances are adding to the distribution grid from a typical modern home are taken into consideration while choosing them. In addition to the previously listed, the following are other contributions. The sensors and electrical parts are distinct from those in [14], and a regular inductor is only utilised in dc/dc operation.

The operation of solar PV batteries is confirmed while taking into account variations in solar radiation. The circulation current ismitigated due to operation of the switches in the topology for dc/dc operation. Control logic and sampling of input quantitiesare also different in this paper.

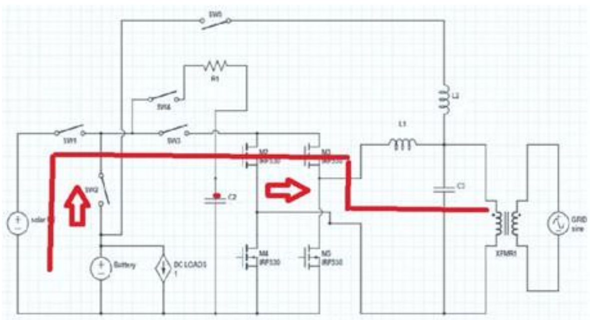

Fig. 2. PV to grid

The suggested inverter circuit, its modes of operation, and an analysis are presented in Section II. The suggested converter's control and the essential design considerations to update it are covered in Section III. To confirm the suggested topology, Section IV uses experimental outputs to verify the proposed topology. The results are compiled and concluded in Section V.

II.TOPOLOGY OF RSC

Fig. 1 shows the reconfigurable solar inverter's circuit diagram. Even though there will be fewer power conversion stages, this design requires more mechanical switches and cables. Table I lists the modes of operation for the proposed single-phase, single-stage converter. Additionally, Figs. 2–5 display several modes of operation.

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com
ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395
Volume 10 Issue 12 – December 2022 - Pages 14-28

A. Mode-1

The mode of operation as shown in Fig. 2 is directly connects PV to the grid. Maximum power point tracking (MPPT)

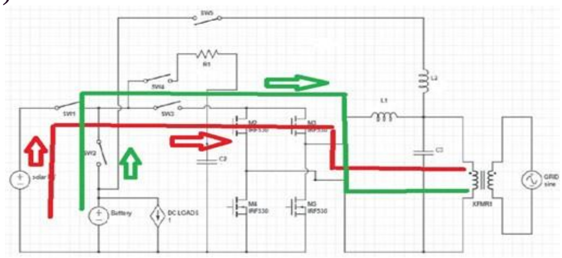

Fig. 3. PV-battery to grid

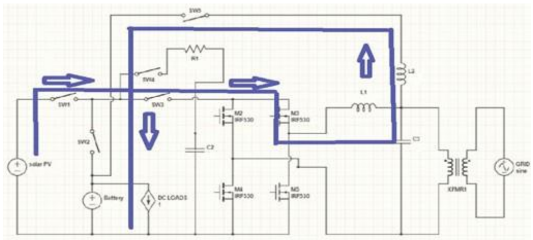

Fig. 4. PV to battery charging

.

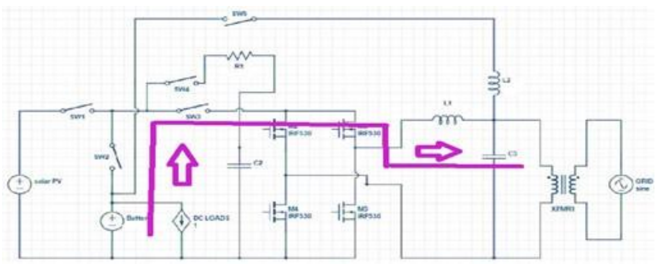

Fig. 5. Battery to grid

Controller is used to extract maximum power from the solar panel. Inverter controller is used to synchronize with grid and transfer active power to grid.

B. Mode-2

In Fig. 3, both solar PV and battery power are used to supply the grid with electricity. This mode kicks in when the solar PV isn't producing enough power because of outside factors like the weather. The requirement that the battery voltage and PV voltage always coincide is one of the connection's disadvantages. The MPPT controller cannot be used in this arrangement due to the stiff battery voltage.

C. Mode-3

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com

ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105

JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

Volume 10 Issue 12 – December 2022 - Pages 14-28

The suggested topology's dc/dc operation is depicted in Fig. 4, where the converter's chopper motion charges the battery. It is optional to add an additional inductor to further minimise charging current ripple. The battery is charged for use at night when there is extra energy available.

D. Mode-4

According to Fig. 5, battery energy can be delivered to the grid or appliances at night or when there is no solar radiation because of clouds or rain. The inverter can get steady electricity from the battery. As a result, it can be quite beneficial for improving power quality and providing auxiliary services.

III. Control of the Proposed Converter

PQ controller is employed to operate this proposed single-phase inverter because of its ability to regulate both active and reactive power in accordance with the reference signal. For effective control, the ac control variables are changed from a rotating reference frame to a stationary one since the regulating elements of the ac system are highly challenging because of their time-varying nature [15].

Let F_α and F_β be the rotating reference frame variables, which can be voltage or current, whereas F_d and F_q are the stationary variables. In rotatory reference frame, the active and reactive powers can be calculated by using

$$P = 1/2\ [v_d \times i_d + v_q \times i_q] \qquad (1)$$

$$Q = 1/2\ [v \times i - v \times i] \qquad (2)$$

where v and i are the instantaneous values of voltage and current, respectively.
When the inverter is synchronized to the grid, the value of v_q becomes 0, and (1) and (2) becomes

$$P = 1/2\ [v_d \times i_d] \qquad (3)$$

$$Q = 1/2\ [v_d \times i_d] \qquad (4)$$

The active and reactive reference currents are given in (5) and (6) as

$$\hat{i}_d = (2\times\hat{P}) / v_d \qquad (5)$$

$$\hat{i}_q = (2\times\hat{Q}) / v_d \qquad (6)$$

where $\hat{P}$ and $\hat{Q}$ are the reference power signals of active and reactive power, respectively.

In order to generate reference signals for the sinusoidal pulse width modulation controller, the calculated values of i_d and i_q are transformed into a stationary reference frame and sent as a signal to the PQ controller. Understanding the phase and magnitude of the grid supply voltage is necessary for synchronizing the solar inverter with the grid. Phase lock loops (PLLs) are used to help synchronize with the grid by tracking its phase. The maximum power transfer theorem states that in order to get the most power out of the solar panel, the panel resistance and the load resistance that is connected to it must be equal. An MPPT algorithm

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com
ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395
Volume 10 Issue 12 – December 2022 - Pages 14-28

for hill climbing is employed to accomplish this. This technique will equalize the resistances and extract maximum power from the solar panel.

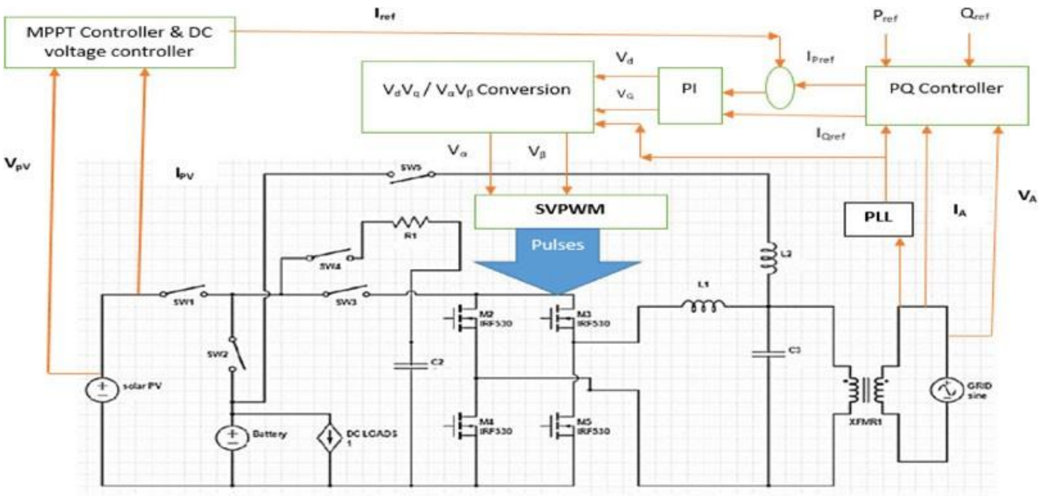

Fig. 6. DC/AC inverter operation

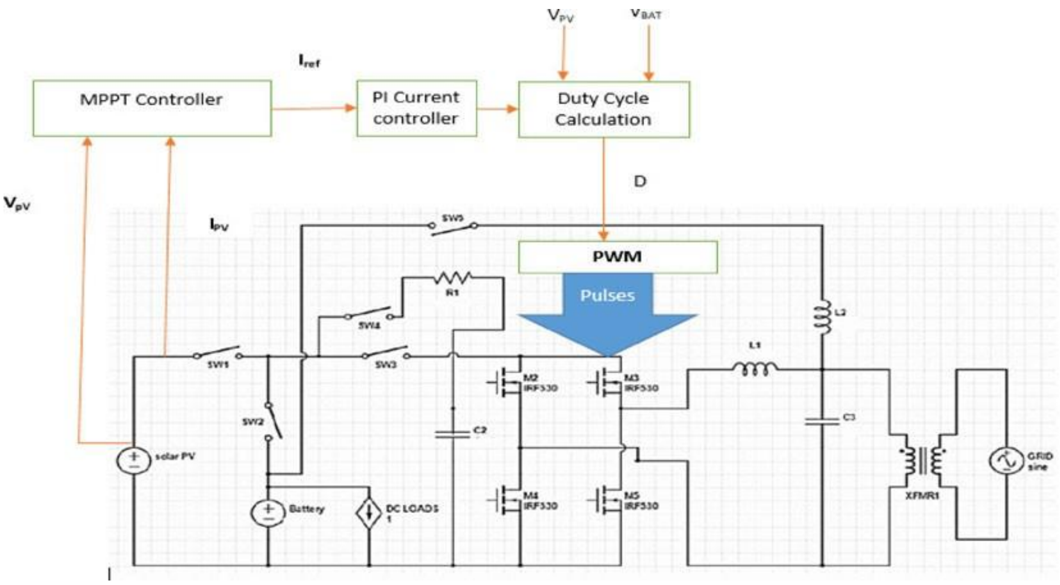

Fig. 7. DC/DC chopper operation.

Figs. 6 and 7 show the control diagram for the various RSC operating modes. The RSC's inverter operation is described in Fig. 6. Using the MPPT algorithm, voltage is adjusted to harvest the maximum power from the solar panel based on current and voltage measurements. A PI controller is tasked with

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com
ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395
Volume 10 Issue 12 – December 2022 - Pages 14-28

regulating the DC link voltage by comparing this voltage to the predetermined DC link voltage and providing the error. The reference current generated by this PI controller is compared to the reference current generated by the PQ controller, which is provided in equations (5) and (6). A PI controller receives this error and uses it to create the reference voltage needed for active power control. A different PI controller is used to independently control reactive power. These reference voltages are converted to rotating reference frame voltagesand given to space vector pulse width modulation (PWM) to drive the inverter.

The battery is charged from the solar panel by use of the RSC's dc/dc conversion mode, as illustrated in Fig. 7. The MOSFET switch is utilised to achieve the necessary voltage level for the battery.

Constant voltage charging is applied here. A PI controller receives the necessary current from an MPPT controller to generate the reference voltage. Duty cycle is produced by comparing this value to the battery voltage. The MOSFET switch receives PWM pulses generated from this duty cycle. Thus, a single reconfigurable inverter supplies power to both ac and dc loads.

The suggested converter is simulated using MATLAB/Simulink. Table II lists the parameters that were used in the simulation. At 1000 W/m2, the radiation is maintained at its maximum. The inverter is controlled via built-in PLL and PWM pulse generator blocks in MATLAB/Simulink. The 500-W inverter topology has been designed. Figure 8 simulates and displays the active and reactive power output for a load of 320 W and 80 VAR.

In order to synchronize the solar inverter with grid, the magnitude and phase of the grid supply voltage must be known PLL is system which will track a signal with other signal system. PLL is actually a servo mechanism which will reduce the differencebetween phase and frequency of incoming signal to a referencesignal. If the inverter's phase and the grid supply system's phase differ, active power transfer to the grid is feasible. An inverter controller is used to create the required phase shift for power transfer once PLL captures the phase of the grid supply. Fig. 9 displays the phasor diagram of the grid supply and inverter during the power transfer.

TABLE II

SIMULATION PARAMETERS

Components	Parameters
Battery	12 V, 9 Ah
Filter capacitor (C1)	47 μF
Filter inductor (L1)	2.3 mH
Switching frequency	4000 Hz
DC link capacitor (C2) 2 nos.	2200 μF, 16 V Resistance (R1)
Resistance (R1)	1kΩ

Solar panel details

No of cells per module	36
Open circuit voltage (V)	22.0 9
Short circuit current (A)	8.36

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com

ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105

JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

Volume 10 Issue 12 – December 2022 - Pages 14-28

Voltage at maximum power (V)	17.7
Current at maximum power (A)	7.62
diode quality factor	1.25
number of series-connected module per module	1
number of modules per string	3
Series resistance (ohm)	0.165
Parallel resistance (ohm)	80

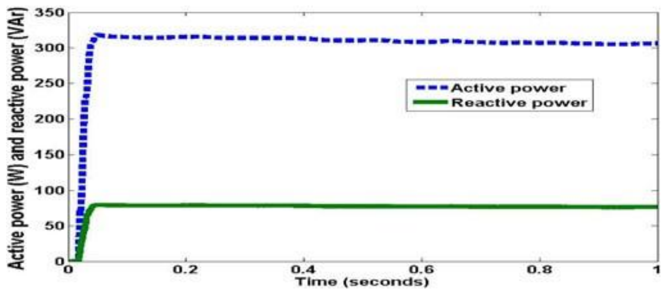

Fig. 8. Active and reactive power generation

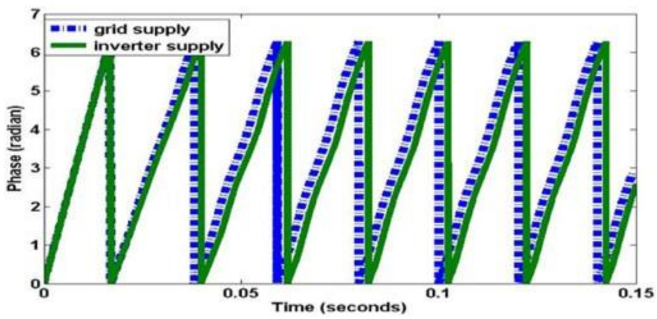

Fig. 9. Phases in radians

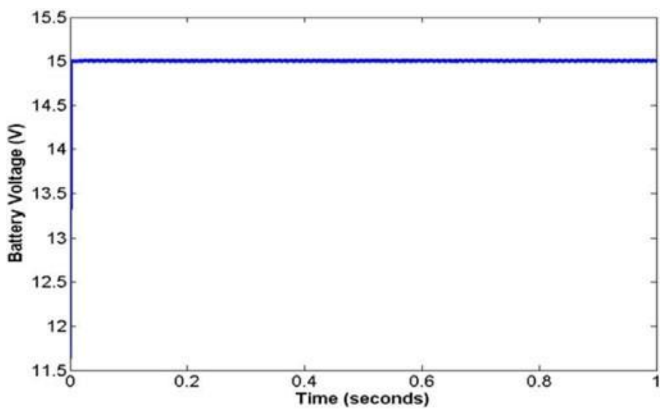

Fig. 10. Battery voltage

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com

ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

Volume 10 Issue 12 – December 2022 - Pages 14-28

TABLE III

HARMONIC CONTRIBUTIONS BY DIFFERENT APPLIANCES

Appliances	THDV (%)	THDI (%)
Air conditioner	3.72	18
Bread toaster	2.3	2.7
CFL bulbs	3.6	99.9
Computer	2.7	99.6
Induction cook top	1.8	3.8
Fan	1.8	1.5
Incandescent bulb	1.7	2.2
Iron box	2.3	2.8
Laptop charger	2.3	39.1
Microwave oven	3.3	22
Mixer	2.9	13
Refrigerator	3	5.2
UPS	2.9	18
Battery charger	2.5	54
Cooler	2.4	1.7
Florescent lamp	2	99.8
Rice cooker	2.2	2.4
Tele vision	3	99.9
LED bulb	2.2	33.8

Using the suggested architecture, the battery was charged. The constant voltage charging approach is used in this instance. A built-in MATLAB/Simulink block called a Li-ion battery is used to store batteries. Fig. 10 shows the output voltage during the charging process. As a result, the converter's entire function is tested virtually, and the outcomes are examined. The MATLAB simulation exhibits flawless operation of the control algorithm.

The empirically calculated harmonic contributions of various appliances are listed in Table III. According

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com
ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

Volume 10 Issue 12 – December 2022 - Pages 14-28

to the chart, the loads that inject more harmonics are connected to the dc supply side and replaced with their dc counterparts. Lighting loads, such as CFLs and tubelights, and charging loads, such as computers and battery chargers, have higher current total harmonic distortions (THDI). Therefore, it avoids injecting harmonics by going around these loads to the DC supply side.

IV.HARDWARE IMPLEMENTATION

In order to verify the suggested topology, the Asian Institute of Technology's Energy Lab in Pathumthani, Thailand, implements RSC hardware. . Fig. 11 shows the hardware circuit diagram. In this experiment, the controller is an Arduino Uno board. This board has an interface connected to

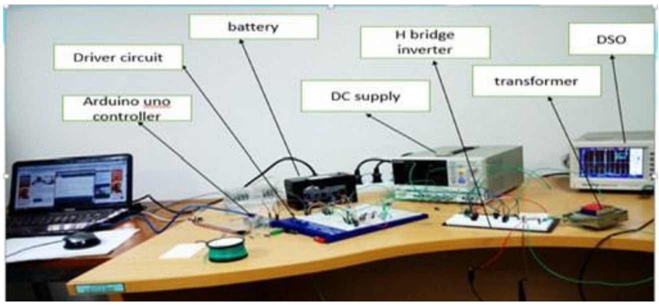

Fig. 11. Experimental setup

Fig. 12. Loads and relays

MATLAB/Simulink environment in order to implement the control logic of RSC. Its built-in analogue and digital input readers and PWM pulse generators would be very helpful in regulating the voltage and phase of the suggested converter. In the lab experiment, solar panels are swapped out for a DC power supply.

To simulate various operating situations, the voltage and current settings of the DC power supply are adjusted to generate varying power levels. Fig. 12 lists the loads and relay that were employed in this experiment. The literature [7] identifies charging and lighting loads as the largest harmonic generating loads in a household. A notable improvement in the harmonic profiles of the residential feeder can be obtained by substituting them with their dc equivalent and connecting them to the dc supply side of the hybrid ac/dc home. Therefore, dc and ac LED bulbs are used as ac and dc loads in this investigation. To demonstrate the harmonic differences between ac and dc charging, a 12-V, 9-Ah battery is utilized for charging loads. The battery is charged through RSC for a dc supply side connection and charged from ac through an adaptor.

The experiment makes use of a SONGLE 4 relay module, each rated at 250 V AC/10 A or 30 V DC/10 A. This relay has a 10 ms operating time. Fig. 13 illustrates a relay's operating time when a pulse from

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com
ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395
Volume 10 Issue 12 – December 2022 - Pages 14-28

a UNO board is supplied for the relay's testing. In mode 1, the voltage is measured using a low-voltage transducer (LV-25), which is connected to the UNO's analogue input, in order to synchronise with the grid. LEM is a well-known manufacturer of current and voltage sensors. The analogue input will read in the MATLAB IDE and generate synchronising pulses using a PWM pulse generator as a result of the interface with MATLAB.This pulse is given to the PWM output pins of the UNO board.

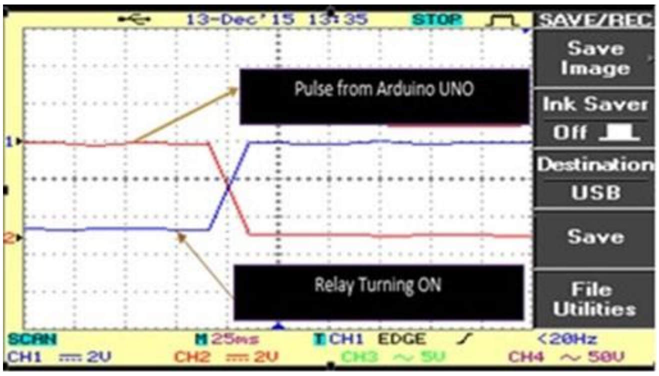

Fig. 13. Relay turn ON

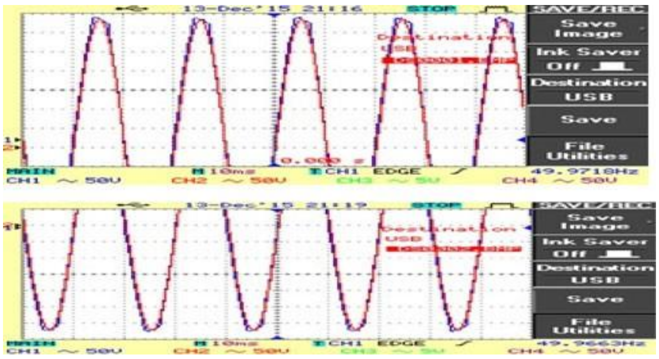

Fig. 14. Grid and inverter voltage

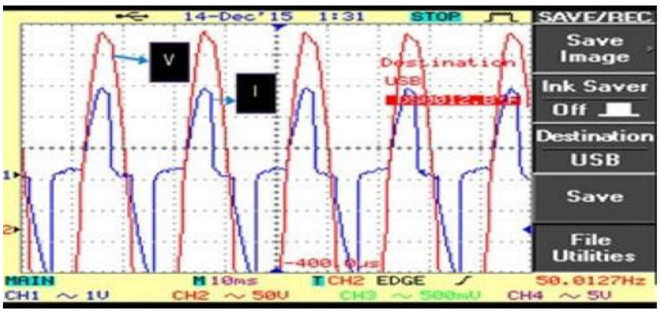

Fig. 15. Unity power transfer to grid

The wave form of grid and interfacing voltage is given in Fig. 14. Since the peak voltage of DSO in the lab is 300 V maximum and so, two waveforms are given in Fig. 14 (upper and lower) to show the synchronization with the grid without any significant deviations.

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com

ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

Volume 10 Issue 12 – December 2022 - Pages 14-28

The grid's voltage and the inverter's voltage are parallel. Fig. 15 depicts the active power transfer with the grid. The DSO is read using a 1-kΩ resistor coupled to a current transducer LA 25-P, whose setting is set to 1/1000.

In Fig. 15, waveform "V" is grid voltage and "I" represents as the inverter current injected to grid for active power transfer. From the figure, the current and voltage are in the phase which will inject the active power to the grid. The rms voltage is 220 Vand current is 1.5-A peak.

The dc/dc operation of the RSC is done by keeping the battery voltage to 15 V as its nominal charging voltage. The input voltage is changed and checked its effects on the proposed topology, which is given in Fig. 16. The DC supply's input voltage is adjusted to mimic variations in solar radiation, but the RSC's output voltage is kept constant, necessitating battery charging. As observed in Fig. 16, this topology is stable and the voltage is stiff. The output voltage, which is 15 V, which is the battery charging voltage, is constant while the input voltage varies between 0 and 30 V. In addition, the dynamic operation is critical to this specific converter topology. In order to examine the dynamic behavior of the suggested RSC design, distinct labels are assigned to different converter topologies.

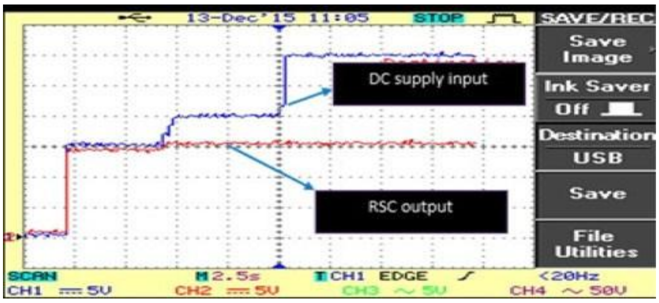

Fig.16. DC/DC operation of the RSC

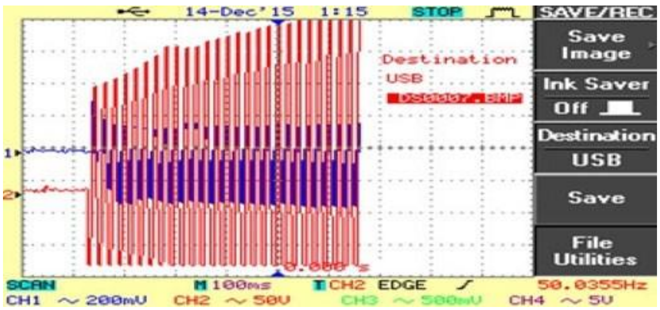

Fig. 17. Mode-0 to Mode-1

A. Mode-0 to Mode1

For instance, the converter's off state is referred to as the Mode-0 stage. Likewise, Mode-1 connects a solar panel to the grid, Mode-2 connects a solar panel and battery to the grid, Mode-3 connects a battery to the grid, and Mode-4 connects a solar panel to a battery for charging. To prevent a significant inrush current during the mode transition, a 1 kΩ resistor is connected in series with the dc-link capacitor.

Fig. 17 depicts how an inverter operates in Mode-0 to Mode-1. After starting in the off state, the inverter is eventually connected to the grid. The inverter voltage is connected to the grid using PLL, and the voltage is 220 V. In order to transfer power, unity power factor current is then injected.

B. Mode-1 to Mode-2

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com

ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

Volume 10 Issue 12 – December 2022 - Pages 14-28

In this mode, the battery is connected with solar panel to share the load. The output waveforms are shown in the Fig. 18. After the relay switched ON, there is momentarily delay to track the voltage which is shown in Fig. 18 as transition. The voltage is 220 V and current is 2-A peaks. The delay in one cycle is the time required for the controller and MPPT controller cannot beused in this mode.

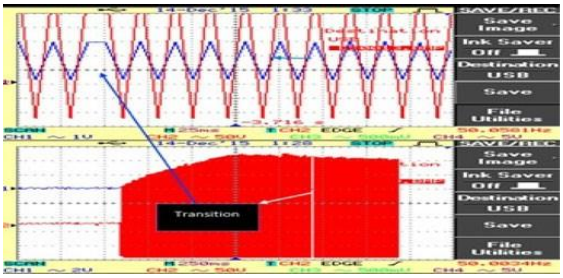

Fig. 18. Mode-1 to Mode-2

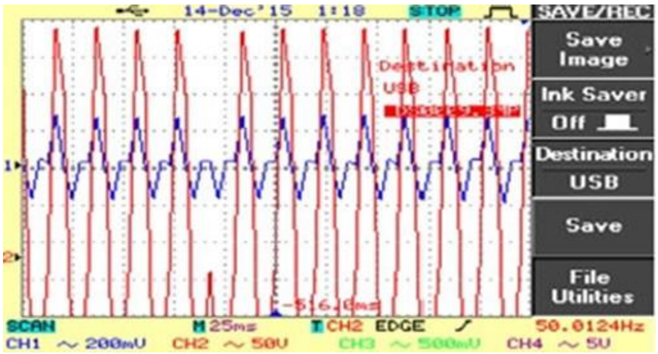

Fig. 19. Mode-2 to Mode-3

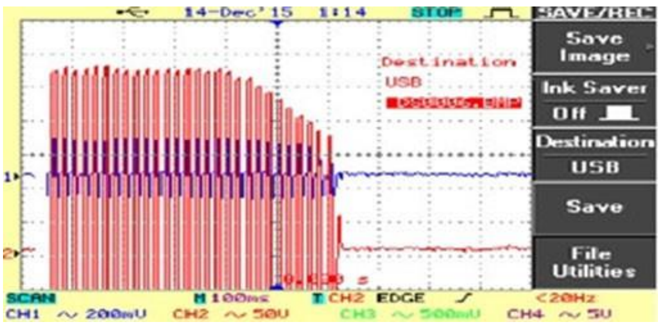

Fig. 20. Mode-3 to Mode-4

C Mode-2 to Mode-3

The transition from Mode-2 to Mode-3 is shown in Fig. 19. The solar panel is removed and battery is powering to the grid.The delay in changes is due to mode transition and controller isset to new stiff voltage by battery

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com
ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

Volume 10 Issue 12 – December 2022 - Pages 14-28

D Mode-3 to Mode-4

In transition to Mode-4 operation from Mode-3, the inverter operation is shut down, which is shown in Fig. 20.

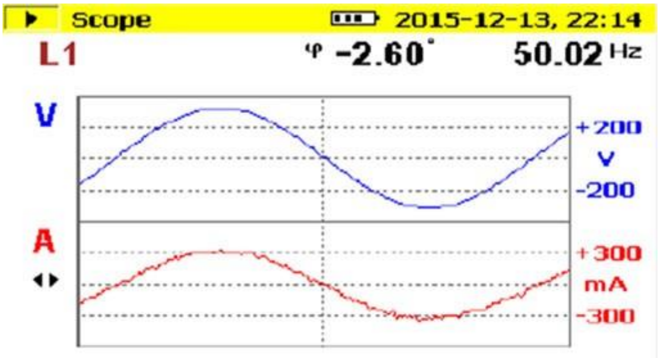

Fig. 21. Voltage and current waveform

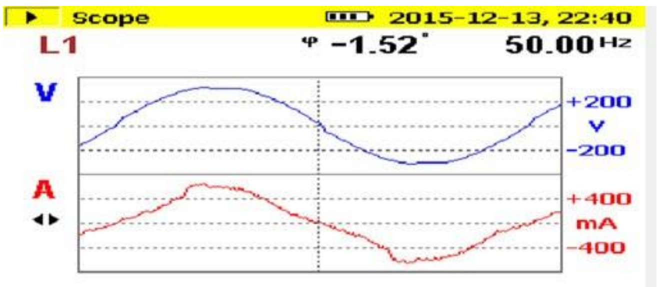

Fig. 22. Voltage and current wave form when battery charged in ac supply .

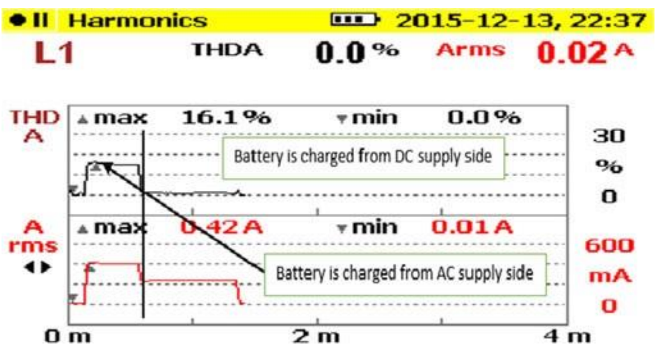

Fig. 23. Harmonic reduction — RSC converter

Consequently, the suggested topology's dynamic state is confirmed using a range of operating modes, from 0 to 4. This suggested converter is tested with both ac and dc loads because it is intended for a hybrid ac/dc home. The output voltage and current waveforms when connected to a 60-W incandescent light are shown in Fig. 21.

When 3-W LED bulb and battery is connected along with this 60-W incandescent bulb, the harmonics are introduces and there is a distortion in wave shape, which can be observed in Fig. 22.When connecting this battery

International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.
Available online at: www.jrrset.com
ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395
Volume 10 Issue 12 – December 2022 - Pages 14-28

and dc equivalent load of ac LED bulb to dc supply side, the total harmonic is reduced significantly (by 16%) as shown in Fig. 23.

The 60-W incandescent lamp is connected in ac supply side throughout this operation. From Fig. 23, it is observed that the THD in current is very high when a battery is charged from ac supply side. When it is removed or moved from ac supply side,the harmonic is reduced to 0 THD.

To power the bulb, the load current drops from 0.42 to 0.3 A. Because of the suggested topology, the single load of a single house can lower the current harmonics (THD) by 16%. Thus, a community can gain a notable decrease in harmonics in the residential feeder by implementing this RSC as their solar converter configuration. 90% of the inverter's dc side is operational, which is more efficient than the 72–80% of dc appliances connected to the ac side. It results from not converting twice. Reducing harmonics also aids in lowering the distortion power.

V CONCLUSION

A better converter topology for a solar-powered hybrid ac/dc home was proposed in this research. Utilising a single transfer of ac power to dc and vice versa improves efficiency, lowers volume, and increases dependability. This topology's basic principle The recommended converter topologies would be useful to minimise a significant amount of harmonics in the future smart grid's residential feeders, as confirmed by the hardware implementation. Although the only power source taken into consideration in this instance is solar PV, similar topology may also apply to wind, fuel cells, etc.

REFERENCES

[1] Renewables 2014 Global Status Report. REN21. [Online]. Avail- able: http://www.ren21.net/Portals/0/documents/Resources/GSR/2014/ GSR2014_full%20report_low%20res.pdf

[2] S. Munir and L. Y. Wei, "Residential distribution system harmonic com- pensation using PV interfacing inverter," *IEEE Trans. Smart Grid*, vol. 4,no. 2, pp. 816–827, Jun. 2013.

[3] J. Von Appen, T. Stetz, M. Braun, and A. Schmiegel, "Local voltage control strategies for PV storage systems in distribution grids," *IEEE Trans. Smart Grid*, vol. 5, no. 2, pp. 1002–1009, Mar. 2014.

[4] A. Arancibia, K. Strunz, and F. Mancilla-David, "A unified single- and three-phase control for grid connected electric vehicles," *IEEE Trans. Smart Grid*, vol. 4, no. 4, pp. 1780–1790, Dec. 2013.

[5] B. T. Patterson, "DC, come home: DC microgrids and the birth of the enernet," *IEEE Power Energy Mag.*, vol. 10, no. 6, pp. 60–69, Nov./Dec. 2012.

[6] V. Vossos, K. Garbesi, and H. Shen, "Energy savings from direct-DC in U.S. residential buildings," *Energy Buildings*, vol. 68, no. Part A,pp. 223–231, Jan. 2014.

[7] N. Sasidharan, N. M. M., J. G. Singh, and W. Ongsakul, "An approach for an efficient hybrid AC/DC solar powered Homegrid system based on the load characteristics of home appliances," *Energy Buildings*, vol. 108,pp. 23–35, Dec. 1, 2015.

[8] B. Mariappan, B. G. Fernandes, and M. Ramamoorty, "A novel single- stage solar inverter using hybrid active filter with power quality improve- ment," in *Proc. 40th Annu. Conf. IEEE Ind. Electron. Soc.*, Oct. 29, 2014–Nov. 1, 2014, pp. 5443–5449.

[9] C.-M. Wang and C.-H. Yang, "A novel high input power factor soft- switching single-stage single-phase AC/DC/AC converter," in *Proc. IEEE Conf. Veh. Power Propulsion*, Sep. 7–9, 2005, p. 5.

[10] K. M. Shafeeque and P. R. Subadhra, "A novel single-phase single-stage inverter for solar applications," in *Proc. 3rd Int. Conf. Adv. Comput. Com-mun.*, Aug. 29–31, 2013, pp. 343–346.

.