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SINGLE-STAGE SINGLE-PHASE RECONFIGURABLE INVERTER TOPOLOGY FOR SOLAR POWERED HYBRID AC/DC HOME

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Abstract- This paper suggests a reconfigurable single-phase inverter topology for a hybrid ac/dc solar powered home. This inverter possesses a single-phase single-stage topology and the main advantage of this converter is that it can perform dc/dc, dc/ac, and grid tie operation, thus reducing loss, cost, and size of the converter. This hybrid ac/dc home has both ac and dc appliances. This type of home helps to reduce the power loss by avoiding unnecessary double stages of power conversion and improves the harmonic profile by isolating dc loads to dc supply side and rest to ac side. Simulation is done in MATLAB/Simulink. Such type of solar powered home equipped with this novel inverter topology could become a basic building block for future energy efficient smart grid and micro grid

Index Terms- mitigation, hybrid ac/dc home, single-phase single-stage inverter, solar photovoltaic (PV).

I. INTRODUCTION

Solar power is fast growing and one of the most important renewable energy; this hugely increases global energy consumption rate in India [1]. Photovoltaics (PV) system is belonging to research and technology related application of solar cells. The solar energy is the energy converting sun energy with sun light and ultraviolet radiation convert directly into electricity using solar cell [2]. The aim of this research work is to increase the power output and efficiency of the PV system. It is also needing of the constant voltage be supplied to the load irrespective of the variation in solar temperature and irradiance. Parallel and series combination of PV arrays are used to generate electricity depending upon the environmental effects (e.g. temperature and solar irradiation) [3]. In solar PV module the efficiency is low [4]. It is necessary to operate on peak power point so that the maximum power can be delivered to the load. The effects of varying temperature and solar irradiation conditions [4]. To increase the efficiency of the system and tracking the maximum power point (MPP) of a photovoltaic (PV) array. The by MPPT techniques is to automatically find the maximum voltage point or maximum current point at which a PV array should obtain the maximum power output under the effects given by temperature and irradiance [5]. The many MPP tracking (MPPT) methods have been developed and implemented. MPPT is a fully electronic system that varies the electrical operating point of the module it capable to deliver maximum available power to the load [6]

To improve the productivity and comfortability, the modern household adds more and more nonlinear equipment, which are also main source of generating harmonics current in distribution feeder. This further adversely affects power quality, power losses and creating a significant challenge for electrical engineers. Modern household loads have different characteristics compared to loads present in earlier stage. However, harmonic mitigation and/or its minimizations are big challenges in distribution system. Many literatures works have been reported to address aforementioned problems as follows. Harmonic mitigation in the distribution system using solar inverter by virtual harmonic damping impedance method is discussed in literature [2]. In [3], PV-battery storage system is used to control the voltage stability in distribution system. The control of solar powered grid connected inverter for electric vehicle charging is suggested in [4]. Patterson [5] has proposed the dc micro grid and shown its advantages and challenges of making a complete dc home micro grid. Further, this paper has analyzed by considering all buildings in 2050, 80% of buildings are already built. So, focus is more on improving the efficiency of existing buildings than making a new complete dc home. Vossos *et al.* [6] has analyzed the efficiency of residential building when it is converted into dc house over the conventional ac distribution house. They analyzed the data of 14 states in the USA,

II LITERATURE SURVEY

Current century has witnessed an unprecedented evolution and growth of renewable energy worldwide. There has been a substantial increase in the capacity and production of all renewable technologies and also growth in supporting policies. Between 2009 and 2013, solar photovoltaic (PVS) experienced the swiftest growth rate in added power capacity among all the renewable.

In particular, rooftop solar PV are gaining more popularity in distribution system due to reduction in cost of solar panel, appropriate government policies such as feed in tariffs promoting renewable energy utilization, modularity, less maintenance, etc. However, the intermittent nature of the renewable causes the significant stability and reliability issues in the distribution system. The restructuring of the electric supply industry has prompted the situation, where customer is a critical business player. To mitigate the uncertainty in solar PV generation, storage options such as battery system and fuel cells, etc., are introduced.

2.1 Existing system

A novel solution to mitigate some of the harmonics related problems and efficiency issues by proposing a hybrid ac/dc home grid system. Conventional grid connected inverter uses high dc link voltage, which will be the peak magnitude of the line–line grid voltage. For this particular purpose, two stage conversions are required to boost up the dc voltage and to invert it. However, this will increase the cost, size, and loss of the system. Transformer less inverter gained significant research interest such that Transformer less inverter has the advantage of low size and cost by avoiding the transformer but this will eliminate the galvanic isolation and inverter will become very sensitive to grid disturbances. The solar PV is limited by its inherent intermittency aspects and, hence, battery storage (assumed here) is required to supply the power when there are not enough solar radiations. Hence, a three-phase topology of reconfigurable solar inverter for utility PV system with battery storage. This reconfigurable system is suitable to solar and wind farm applications. This topology is tested with a new algorithm and validated the results. Normally, every solar powered household have a battery system to provide a reliable supply system. These batteries are charged when connected to ac system or they need a separate converter to manage the charging operations when it connected to dc supply side.

2.2 Proposed system

The main contribution of this paper is to implement a single-phase single-stage solar converter called reconfigurable solar converter (RSC) in the solar powered hybrid ac/dc residential building with energy storage devices. The basic concept of the RSC is to use a single power conversion system to perform different operational modes such as solar PV to grid (Inverter operation, dc–ac), solar PV to battery/dc loads (dc–dc operation), battery to grid (dc–ac), battery/PV to grid (dc to ac) and Grid to battery (ac–dc) for solar PV systems with energy storage. This inverter is tested in a solar powered hybrid ac/dc home, which contains both ac and dc household loads. Vossos *et al.*[6] has analyzed the efficiency of residential building when it is converted into dc house over the conventional ac distribution house. They analyzed the data of 14 states in the USA, which used 380- and 24-V voltages for dc distribution in homes. There is a 33% savings when the ac equipment is replaced with dc equipment. But replacing all existing home appliances with its dc equivalent is not possible due to the high price and unavailability of the required standards/flexibilities of equipment. Sasidharan *et al.* [7] propose a novel solution to mitigate some of the harmonics related problems and efficiency issues by proposing a hybrid ac/dchome grid system. A solar home is discussed as a case study and a 12% improvement in efficiency and a 20% reduction in harmonics are achieved by shifting dc loads to the dc supply side. Parkhideh and Kim [16] provide very brief info but no details/outcomes are available about single-phase single-stage topology, which can supply both ac and dc loads in literature Therefore, the main contribution of this paper is to implementa single-phase single-stage solar converter called reconfigurable solar converter (RSC) in the solar powered hybrid ac/dc residential building with energy storage devices.

III. PROJECT DESCRIPTION

3.1 Solar Photovoltaic Array

A single-phase inverter and boost converter using modelling. The panel output is given to the boost converter after boosting the voltage is connected to invert and then supply to load. In this MPPT algorithm switching pulse generated and given to the boost converter for varying the duty cycle of the boost converter. The interfacing with renewable energy sources is also possible for different solar panels can be feed to the inverter as a dc source [8]. The power coming from battery backup is given to inverter through a bi-directional dc-dc converter; the controlled flow of electrical power in either direction is possible by varying duty cycle.

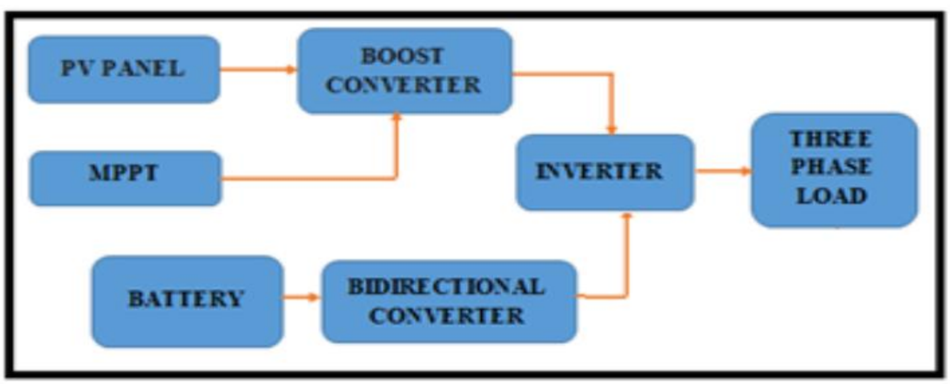
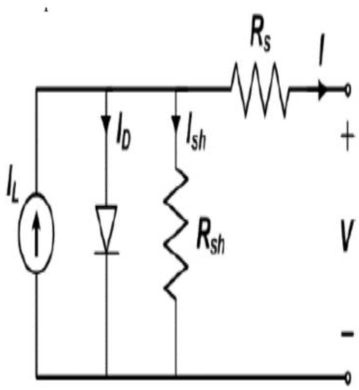


Fig.1 Block Diagram of MPPT Techniques based Photovoltaic System

The Solar Photovoltaic Array is formed by connecting several solar panels in series and parallel combination to generate the required power. The smallest component of the solar photovoltaic array is called photovoltaic (PV) cell. The ideal solar photovoltaic cell is represented by the equivalent circuit shown in Fig 2. These cells are connected in series of 36 or 72 cells to form one module. Similarly, several modules are assembled into a single structure to form array. Finally, assembly of these photovoltaic arrays are connected in parallel to obtain the required power. In PV module, series resistance (Rs) is comparatively more predominant and Rsh is considered equal to infinity ideally. The open circuit voltage (Voc) of the PV cell is directly proportional to solar irradiation and Voc is inversely proportional to the temperature.



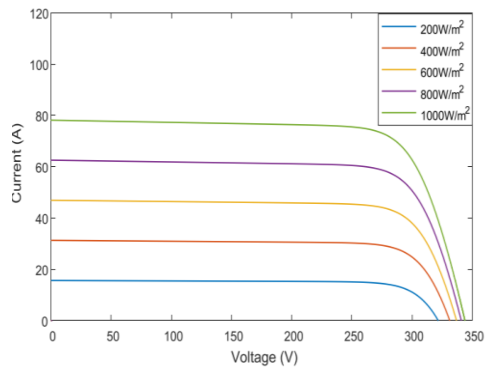


Fig 2: Equivalent circuit of PV cell **Fig 3:** I-V characteristics of 20kW PV Array at different irradiation levels

Single-Stage Solar PV Inverter for Small-Scale Systems Compared to the single-stage one, the multistage power conversion is somewhat more expensive and affects the efficiency of the PV inverter. To reduce the volume and weight as well as the power conversion loss and cost, a hybrid PV battery-powered DC bus system was proposed in 2009 [2]. The DC to AC conversion stage less DC bus system is very applicable to electronic equipment and appliances with high system efficiencies. The PV-batterypowered DC bus system is shown in Fig. For AC systems, a single-stage PV inverter was proposed in [2], and the circuit topology of single-stage inverter is shown in Fig. The proposed inverter performs a dual function: MPPT and outputting a sinusoidal current, which makes the control circuit complex. In [2], an alternative control technique was developed to reduce the complexity of the control circuit. However, the common-mode issue was not considered in the proposed single stage inverter systems. The neutral point clamped (NPC) converter topology has the opportunity to connect the grid neutral point to middle point.

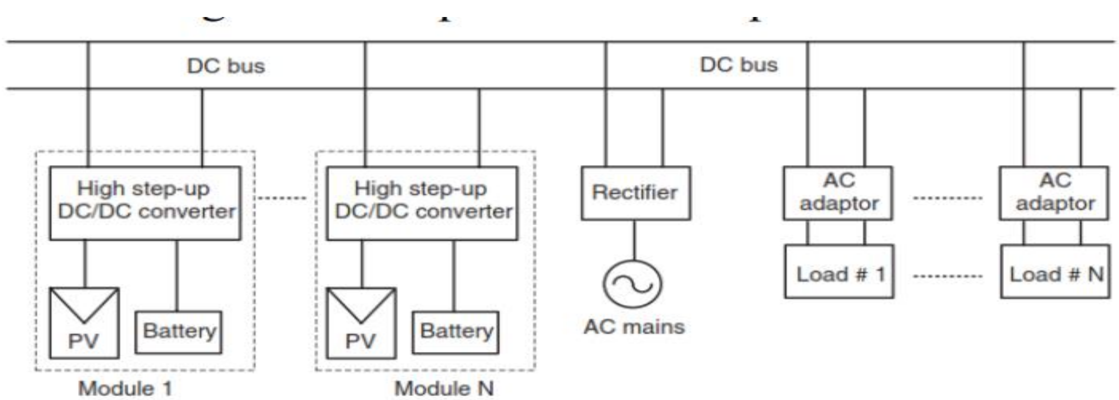


Fig 4 PV-battery-powered DC bus system

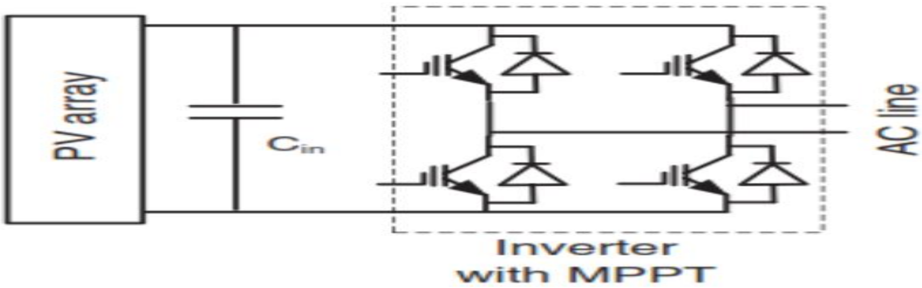


Fig 5 Full-bridge with MPPT-based circuit topology of single stage inverter

$$V_A = \sqrt{2} V_{rms} R. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Therefore, a few PV arrays in series connection are necessary to obtain the desired voltage. From the available literature, several single-stage topologies have been proposedbased on either boost or buck–boost configurations. An integrated (boost converter and full-bridge inverter) PV inverter circuit topology shown in Fig. was presented in [3]. The output power quality and the efficiency of the inverter are limited by the fact that the boost converter cannot generate the output voltage lower than the input voltage. A universal single-stage PV inverter shown in Fig. was presented in that can operate as a buck, boost, or buck–boost converter. This inverter can operate with a wide range of input voltage, improving the power quality and the efficiency. Using the integratedbuck–boost and inversionfunctions, several modified configurations have been presented in [3]. However, these topologies are only suitable for small-scale (e.g., <100 kW) PV systems, where the PV array normally interconnects with a low-voltage public network.

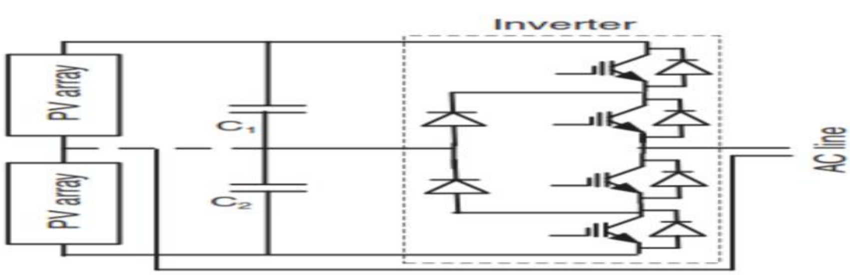


Fig 6 Single-stage power circuit with boost converter

IV. SIMULATION RESULT

V. Mode-1:PV-Grid

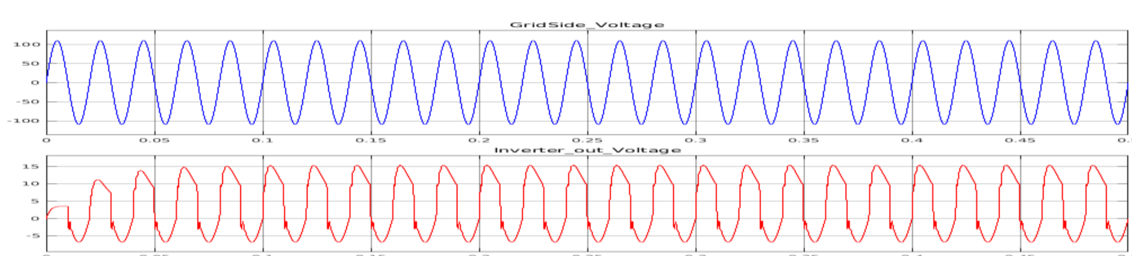


Fig. 7. Grid side voltage and inverter out voltage in PV Grid Mode.

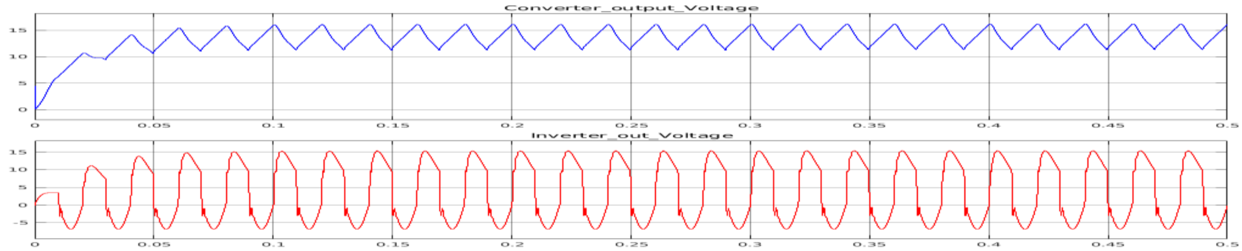


Fig. 8. Converter and Inverter output voltage PV Grid mode

- **Mode -2: PV-Battery-Grid**

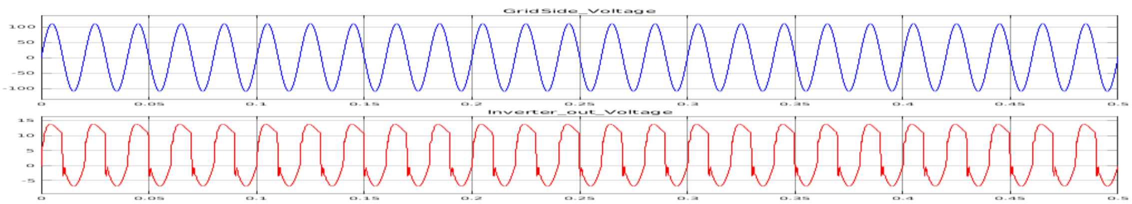


Fig. 9. Grid side and Inverter output voltage PV-battery- Grid mode.

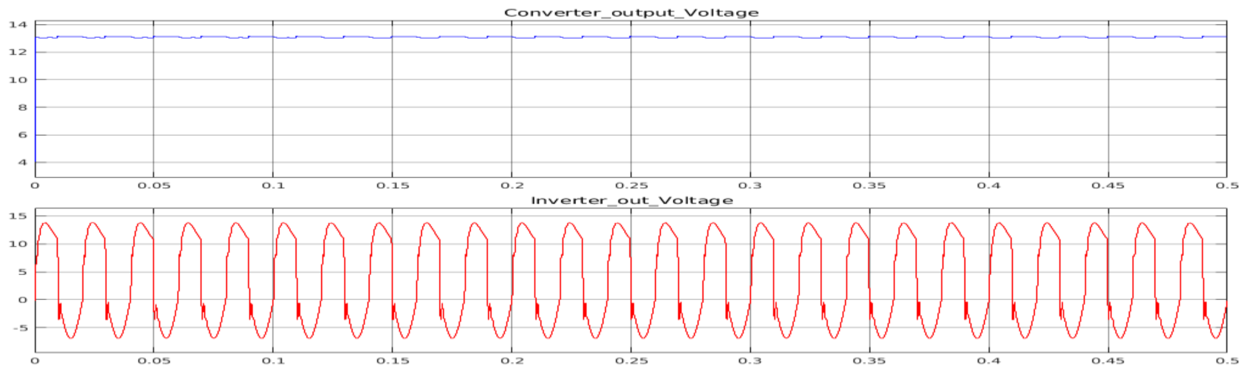


FIG. 10. Converter and Inverter output voltage PV-battery- Grid mode.

Fig. 11. Active Reactive power in PV-battery- Grid mode.

- **Mode -3: PV-Battery**

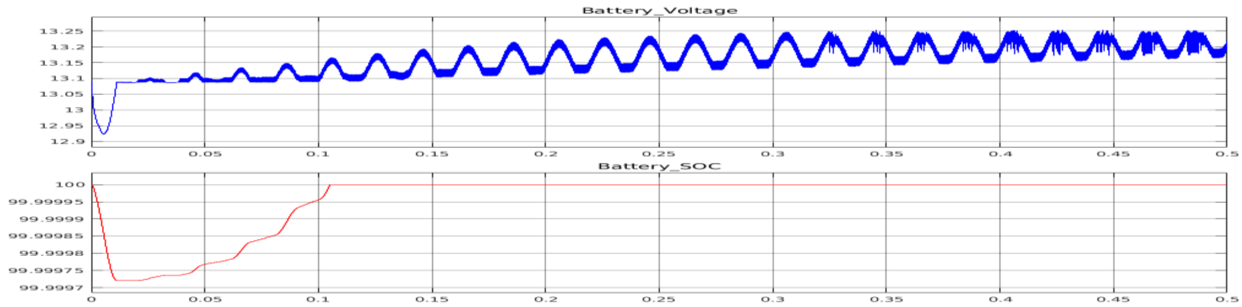


Fig. 12. Battery voltage and battery SOC in PV-battery- Grid mode.

- **Voltage and Current.**

waveform "V" is grid voltage and "I" represents as the inverter current injected to grid for active power transfer. The current and voltage are in the phase which will inject the active power to the grid. The rms voltage is 220 V and 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.

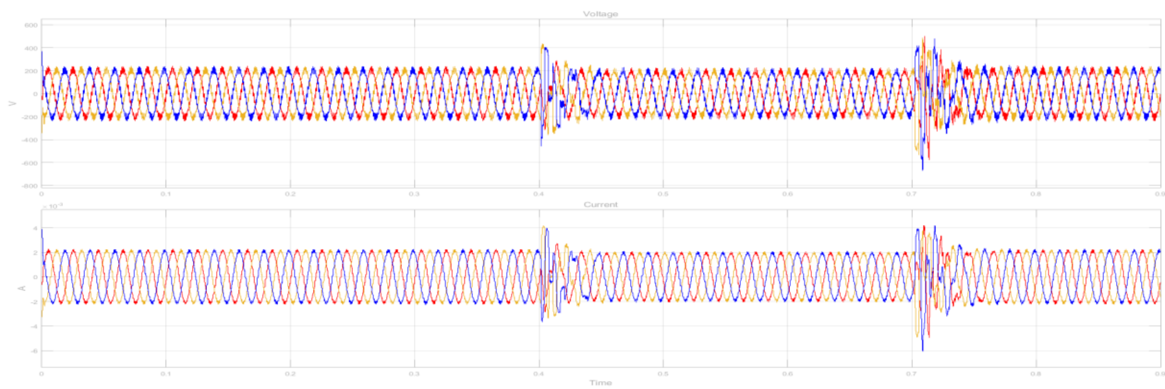


Fig. 13. Voltage and current waveform.

VI. CONCLUSION

4.1 Advantages

- it minimizes the number of conversion stages
- improving efficiency and reducing cost, weight, and volume
- Helps to reduce the power loss avoiding unnecessary double stages of power conversion
- Improves the harmonic profile by isolating dc loads to dc supply side and rest to ac side.

4.2 Conclusion

This paper suggested a more suitable converter topology for asolar powered hybrid ac/dc home. Themain idea of this topologyis to utilize single conversion of ac power to dc and vice versa,which improves the efficiency, reduces volume, and enhancesthe reliability. The hardware implementation validates that thesuggested converter topologies would be helpful to reduce significantnumber of harmonics in the residential feeders of thefuture smart grid. Though, here only solar PV is considered assource of power, this topology could be equally applicable towind, fuel cells, etc.

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