A Single Stage Single Phase Inverter in Hybrid System

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Abstract- **A single phase inverter topology for a hybrid AC/DC solar powered home. In single phase inverter topology, transformer less inverter gained significant research interest. The main advantage of this single stage single phase inverter is that it can perform DC/DC, DC/AC and grid tied operation. This hybrid AC/DC home has appliances of both AC and DC types. In this inverter the conversion of AC to DC and boosting of DC voltage is done in single stage. To reduce the power loss by avoiding unnecessary double stages of power conversion and improves the harmonic profile by isolating DC type loads to DC supply side and rest of AC side. The Simulation is done in MATLAB/Simulink and secondly, obtained results are validated with hardware implementation using PIC Micro controller. Such type of solar powered home and inverter would be a basic building block of energy efficient future Smart Grid and Micro grid.**

Index Terms- **Single stage single phase inverter, Solar energy, Wind energy, Sepic converter, Harmonic mitigation.**

I. INTRODUCTION

The current century has witnessed the 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- 2013, solar PVs experienced the swiftest growth rate to have added power capacity amongst all the renewables. Especially, rooftop solar PV are gaining more popularity in distribution system due to reduction in cost of solar panel, Government policies such as feed in tariffs to promote renewable energy utilization, modularity and less maintenance etc. But 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 are introduced such as battery system, Fuel cells etc.

Due to growing of nonlinear modern household equipment and new technologies in houses, which needed to improve productivity and comfortability, are main source of generating harmonics current in distribution feeder and that adversely affecting the power quality, power losses along with 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. Harmonic mitigation in the distribution system using solar inverter by virtual harmonic damping impedance method is discussed in literature. In 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. The DC micro grid and shown its advantages and challenges of making a complete DC home micro grid. Further, this paper has analysed 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 and has analysed the efficiency of residential building when it is converted into DC house over the conventional AC distribution house. 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. It proposes a novel solution to mitigate some of the harmonics related problems and efficiency issues by proposing a hybrid AC/DC Home 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.

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 req uired to boost up the DC voltage and to invert it. However, this will increase the cost, size and loss of the system. To avoid this, single phase single stage topologies of inverter are used. In single phase inverter topology, transformer less inverter gained significant research interest. 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 in the galvanic isolation and inverter will become very sensitive to disturbances in grid connected mode.

The solar PV is limited by its inherent intermittency aspects and, hence, battery storage is required to supply the power when there are not enough solar radiations. But having a separate converter for battery's power management system will increase the cost and size of the converter as well.

This hybrid system is suitable to solar and wind farm applications. This topology is tested with a new algorithm and validated the results. Normally 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. Though, it provides very brief information outcomes are available about single phase single stage topology which can supply both AC and DC loads in literature.

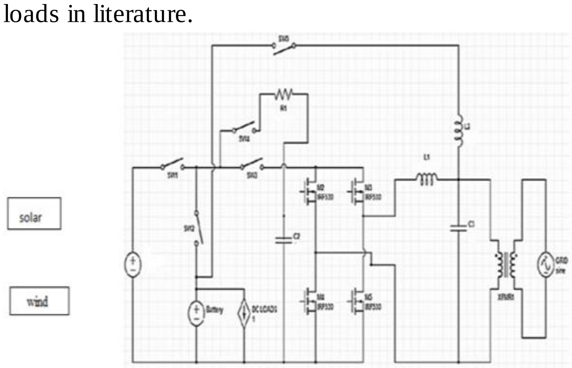


Figure 1. Circuit diagram of single phase inverter

III. TOPOLOGY OF SOLAR CONVERTER

The modes of operation of the single stage single phase topology converter are given in the table.

TABLE - MODES OF OPERATION

Modes of operations	ON switches	OFF switches
PV- GRID	SW1 SW3 SW4	SW2 SW5
PV- BATTERY -GRID	SW1 SW2 SW3 SW4	SW5
PV- BATTERY	SW1 SW3 SW5	SW2 SW4
BATTERY- GRID	SW2 SW3	SW1 SW4 SW5

MODE 1: PV to Grid

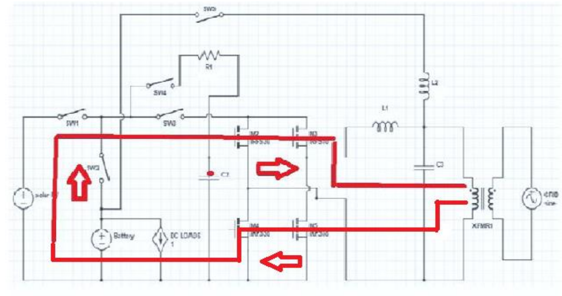


Figure 2. PV to Grid

The mode of operation is in the above figure directly connects PV to the Grid. Inverter controller is used to synchronise with grid and transfer active power to the grid.

MODE 2: PV-Battery to Grid

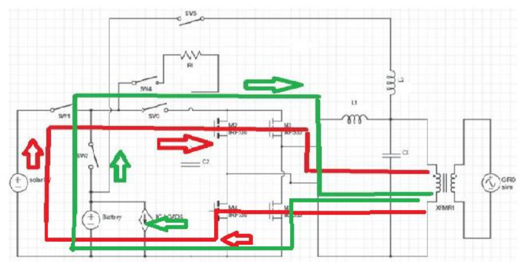


Figure 3. PV – Battery to Grid

In the above figure the mode of operation is to supplying power to the grid from both solar PV and battery. This mode operates when there is a shortage to power from the solar PV due to external conditions.Eg.Weather etc...

MODE 3: PV to Battery Charging

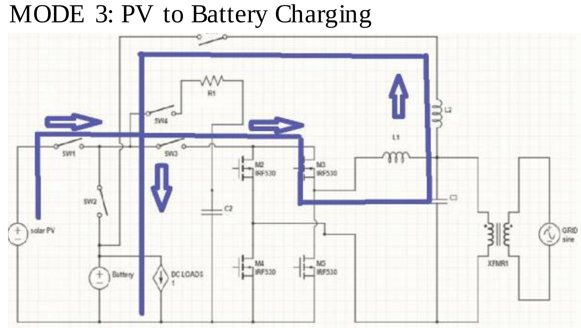


Figure 4. PV to Battery Charging

In the above figure DC to DC operation of proposed topology where battery is charged by a chopper action of the converter. When there is an excess energy available the battery is charged for the night time usage the extra inductor is optional to reduce ripple in the charging current.

MODE 4: Battery to Grid

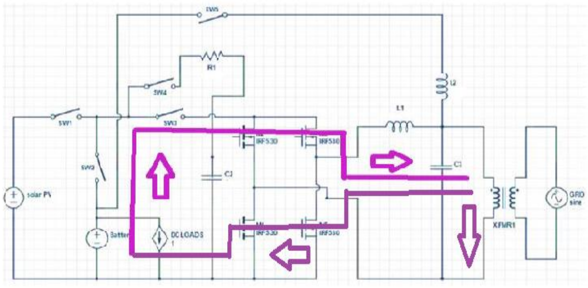


Figure 5. Battery to Grid

In the above figure the energy stored in a battery can be released to the appliances are grid during the night hours or when there is no solar radiation due to cloud or rainy condition. Battery can supply stable power to the inverter.

IV.SIMULATION OF THE PROPOSED INVERTER

The Sinusoidal Pulse Width Modulation (SPWM) is a well-known wave shaping technique in power electronics for realization, a high frequency triangular carrier signal, V1, is compared with a sinusoidal reference signal, V, of the desired frequency. The crossover points are used to determine the switching instants. The magnitude ratio of the reference signal (Vr,) to that of triangular signal (Vc) is known as the modulation index.

The magnitude of fundamental component of output voltage is proportional to mi.The amplitude Vr, of the. Triangular signal is generally kept constant. By varying the modulation index output voltage is controlled.

The pulse width modulation technique is applied to control the output voltage of the inverter which is also known as variable duty cycle regulation.

Generation of the desired output voltage is achieved by comparing the desired reference waveform (modulating signal) with a high-frequency triangular 'carrier' wave as depicted schematically. Depending on whether the signal voltage is larger or smaller than the carrier waveform, either the positive or negative dc bus voltage is applied at the output. Note that over the period of one triangle wave, the average voltage applied to the load is proportional to the amplitude of the signal (assumed constant) during this period. The resulting chopped square waveform contains a replica of the desired waveform in its low frequency components, with the higher frequency components being at frequencies of a close to the carrier frequency. Notice that the root mean square value of the ac voltage waveform is still equal to the dc bus voltage, and hence the total harmonic distortion is not affected by the PWM process. The harmonic components are merely shifted into the higher frequency range and are automatically filtered due to inductances in the ac system.

The Figure 6. given below discuss about the simulation circuit of single stage inverter in hybrid energy. In this simulation circuit, hybrid energy called solar energy and wind energy is used. The output from the solar and wind is given as input to this simulation circuit. In this MOSFET (Metal Oxide Semiconductor Field Effect Transistor) switches issued. The switches is controlled by the pulses, the special techniques used to control the pulses is that "sinusoidal pulse width modulation" techniques.

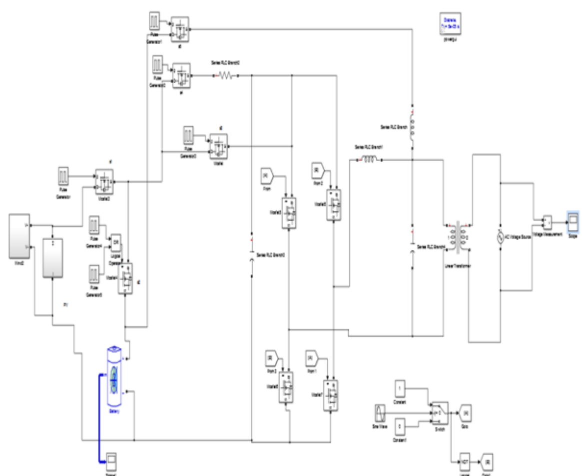


Figure 6. Simulation of Single Phase Inverter

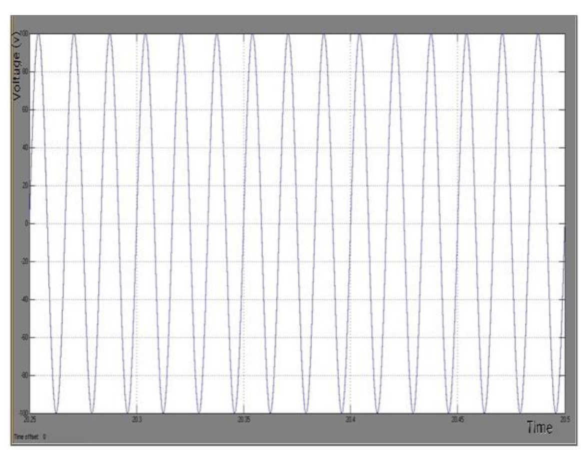
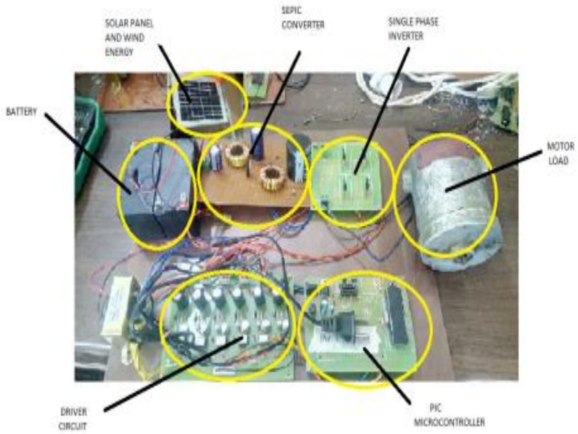


Figure 7. Output Voltage Waveform

V. HARDWARE IMPLEMENTATION



The hardware circuit is designed with the single phase inverter and PIC microcontroller. The designing plan is done to have the hardware circuit to be compact and it can be controlled.

The data is fed to the driver circuit through the PIC controller from port C. The pulses is generated based on the data (0.02 delay) to the single phase inverter. According to this the motor load operates. The DC side of the inverter shows 91% of efficiency which is higher than when DC appliances when connected in AC side which is 72-80%. It is due to avoiding the double conversion. Harmonics also helps to reduce the distortion power.

VI. CONCLUSION

In this project, we have proposed to use the two forms of hybrid energy that is wind energy and solar energy to run the load in both AC and DC. The single stage single phase inverter is used to avoid double stages of power conversion. The main purpose of using single phase inverter is to improve the efficiency, reduces volume and enhances the reliability. In addition to this the simulation is done using MATLAB Software. The harmonics is reduced by implementing SPWM technique. By FFT analysis the harmonics is reduced about 0. 19%, which is very low.

Therefore the proposed technique can be advantageously used to reduce the losses and the overall efficiency is improved.

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