SINGLE PHASE PV MICRO GRID INVERTER WITH BACK UP BATTERY

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ABSTRACT

Distributed generation system incorporating sustainable energy resources have garnered awareness these days due to their advantages. The generation systems are linked to the grid with the help of grid-tie inverters. Since Photo Voltaic system is insufficient by its irregular characteristics of power generation, battery storage is required to supply power when there is no enough sun based radiation. Here grid inter-connected single phase reconstructable inverter topology is designed and considered for efficiency. The essential idea of this system is to use a single power conversion system to achieve functional forms and mods for eg. solar Photo Voltaic to grid, solar Photo Voltaic to battery, battery to load and Photo Voltaic-battery to load for PV system with battery. For performing and achieving this a grid control method by using DQ control approach is performed. A harmonic analysis is implemented to evaluate the harmonic distortion during grid synchronization of given out energy resource. This procedure is demonstrated graphically using MATLAB.

Keywords: *Distributed generation; Reconfigurable inverter; single stage; harmonic analysis*

I. INTRODUCTION

Renewable or sustainable power production is garnering attraction these days due to their advantages. Solar and wind energy resources are among the most famous and reliable distributed power generation factors of which solar energy has found more applications. To tackle the intermittence problem a power storage system like battery can be added to overcome this. Apart from its standalone application, the solar panels are connected to grid in order to supply excess power to grid. Grid inter-connection of solar panels is done using grid tie inverters. These inverters can be used for three phase and single phase. Many methods of grid interconnection are reviewed in the texts. Standard grid connected inverters use two stage topology which consists of a dc-dc and dc-ac conversion setup. But such framework can increase size, price and reliability of the system. Due to these cases the single stage systems are considered over a two stage system. A customizable modular inverter layout for distributed energy systems has been explained in [3].

The inverter topology uses MPPT algorithm to obtain maximum power from solar array since the power output of solar panel changes with the amount of solar radiance and temperature. Many MPPT operating procedures are shown in literature works [4-6]. Among these, Perturb and Observe and Incremental Conductance are the most frequented algorithms due to ease of use and execution [5, 6]. With the instigation and success of distributed generation technologies, different ways of inverter control methods have been developed for controlling grid connected inverters. Instantaneous current can be controlled accurately using current control methods. A DQ frame controller is mostly put forward because it allows easy PI structures which operate on DC variables to be used for controller [7-11].

In this research a recontructable inverter topology which is connected to a one phase grid is shown. The primary goal of the system is to use a one power conversion stage to execute various modes of operation such as solar Photo Voltaic to grid, solar Photo Voltaic to battery, battery to load and battery-Photo Voltaic to grid for solar PV systems with power storage. With MATLAB the simulation of the system is designed and executed, and the results of different modes are presented. Differentiation in solar irradiance is considered and the total harmonic distortion for the various modes is seen. The setup and its modes of operation are explained in section ll. Section III introduces the control circuit for grid integration and maximum power point tracking. The setup is corroborated in topic IV and harmonic analysis are implemented. Section V provides summary and conclusion of the processes.

II. INVERTER TOPOLOGY

The diagram of the system is shown. Conventional single phase inverter topology is revamped to carry out various modes which provide flexibility in operation.

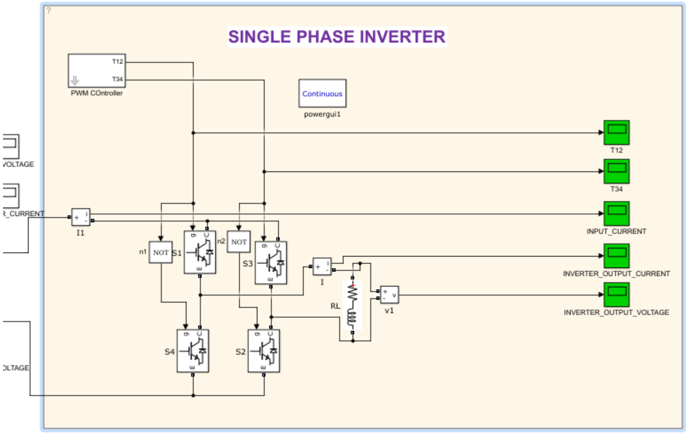


Fig: Block diagram of grid connected inverter

The presented topology requires additional cables and mechanical switches when compared to conventional PV inverter. Various modes of operation are explained below.

1. Mode I

The PV panel is directly linked to the network as shown in this mode. The circuit is completed by connecting the switches sw1, sw3 and sw4. The MPPT control and DC/AC conversion is being controlled by the inverter. The grid is being synchronized by the inverter control.

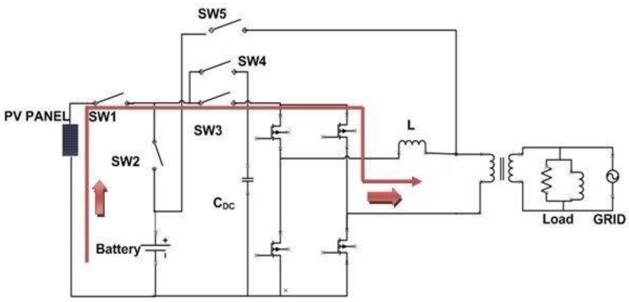


Fig: PV panel to Grid

2. Mode II

The power to the load is being supplied by the battery in this mode. The switches (sw1, sw3and sw4) are in conduct as shown. This mode can be employed whet here is no existence of solar power.

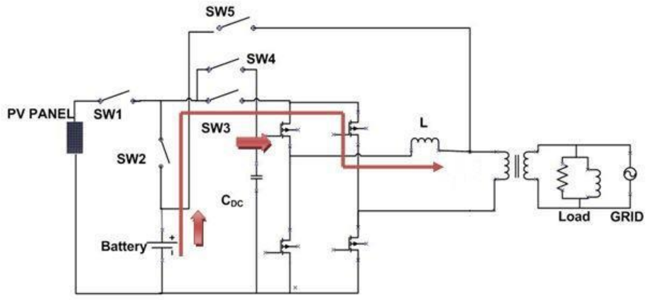


Fig: Battery to Load

3. Mode III

When there is enough of solar irradiance is present the battery is being charged from the PV panel in this mode. The amount of charging is been carried out through one of the inverter switches which provides DC/DC conversion. The switches (sw1, sw3and sw4) are in conduct as shown.

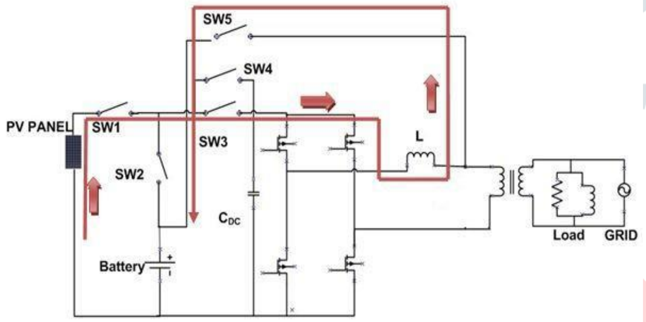


Figure 2.3 Battery charging from PV

4. Mode IV

The panel to the grid has a storage unit system such as battery is connected. This is to make sure that there is enough power is being supplied to the load during the low irradiance or any atmospheric conditions.

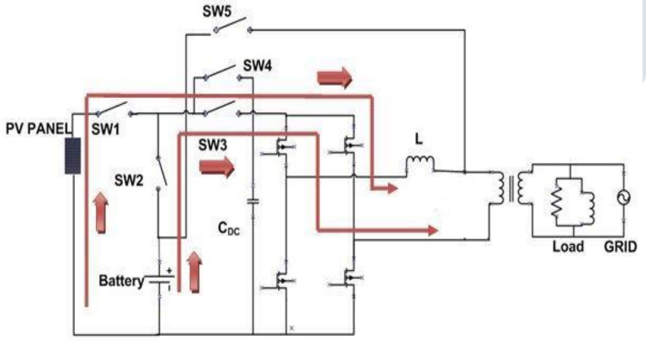


Fig: PV panel-battery to grid

The switches that are present are kept closed to carry out the operation accordingly. In this the battery voltage and the PV voltage should be matching each other. The inverter that is present carries out the DC/AC conversion. Ther battery which is present, automatically gets connected when the solar power falls down below the threshold.

II. CONTROL OF INVERTER

Two control loops are present in the inverter topology for DC/AC control and DC/DC control. A linear current control is employed using dq rotating synchronous frame approach for DC/AC conversion mode.The transformation abc-dq uses the phase angle so that the controlled output current is n the phase with the grid voltage. Through the MPPT controller and the PI controller the instance of direct axis current is obtained. The obtained reference current is compared in contrast with the actual transformed DC component current to the direct axis voltage reference Vd. The quadrature axis reference current and transformed q-axis current is being compared by using the quadrature axis reference voltage Vd. The voltage vectors Vd and Vq are being transformed to the synchronous frame and they are used to generate the PWM pulses to the converter present. PLL is being used to synchronize the inverter to the grid.The control block diagram is being shown below. The MPPT method is being used to attain the maximum power from the solar panel which reduces the complexity and also has the fast convergence.

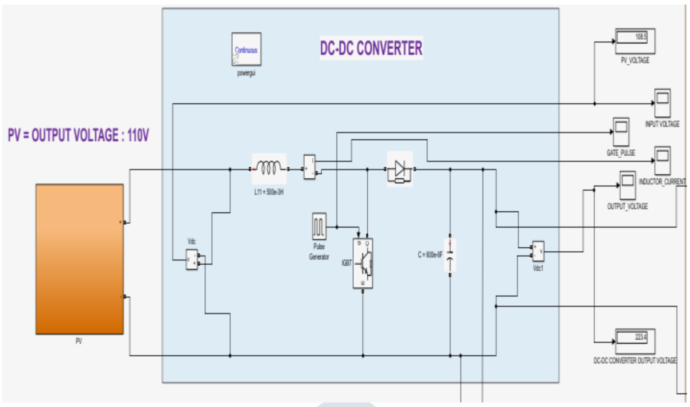


Fig: DC/DC control of inverter

The DC/DC control is charged by the battery the voltage level for charging is being provided by the control. Reference voltage is generated using the MPPT controller and this voltage is compared with the battery voltage to obtain the pulses for inverter switch.

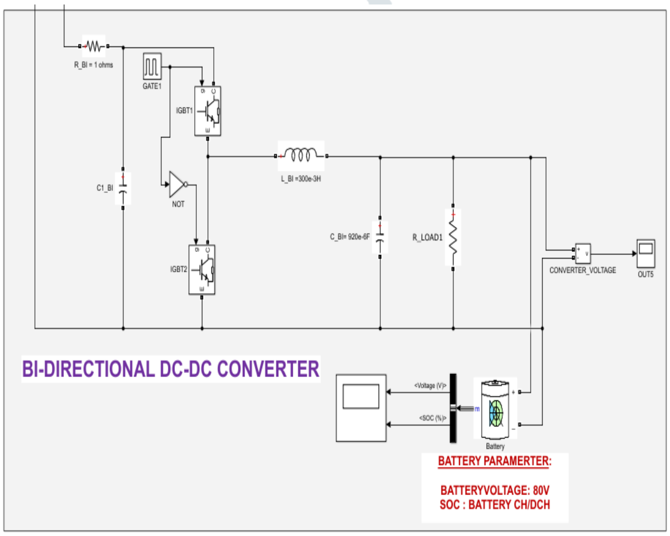


Fig: BI-DIRECTIONAL DC-DC battery backup

III. SIMULATION RESULTS

The presented topology is simulated using MATLAB/Simulink. A PV panel is connected to single phase grid using a 3500 VA inverter. The PV panel delivers a maximum power of 850 watts for an irradiance of 250 W/m2 at 25 °C. It consists of 1 parallel string and 14 series connected modules per string. The power grid model consists of 240V AC voltage source. A 320 watts and 80 VAr load is connected across inverter output. The properties of a PV panel with 1 parallel string and 1 series connected module per string is given in table 1 along with other simulation parameters**.**

Solar irradiance is kept at 250 watts/m2. It is varied to demonstrate different modes of operation. Perturb and Observe MPPT algorithm is employed to track maximum power from solar panel.

1. PV GRID

The inverter voltage during this mode , the phasor diagram of inverter voltage and grid voltage is shown here. The PLL is used to track any changes occurred and is reflected in inverter frequency. The inverter output voltage is being synchronous with the grid voltage. The mode is active and reactive power.

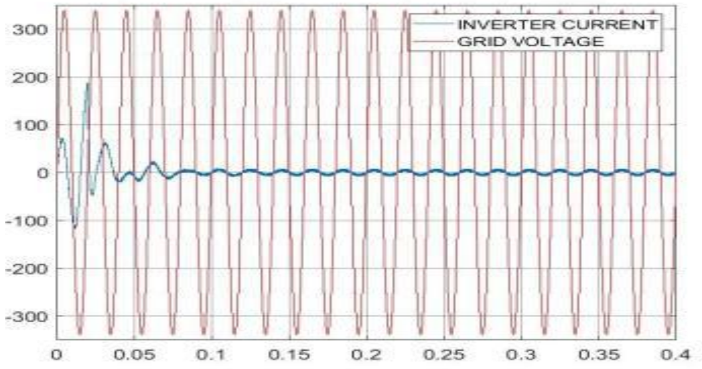


Fig: Inverter current and grid voltage

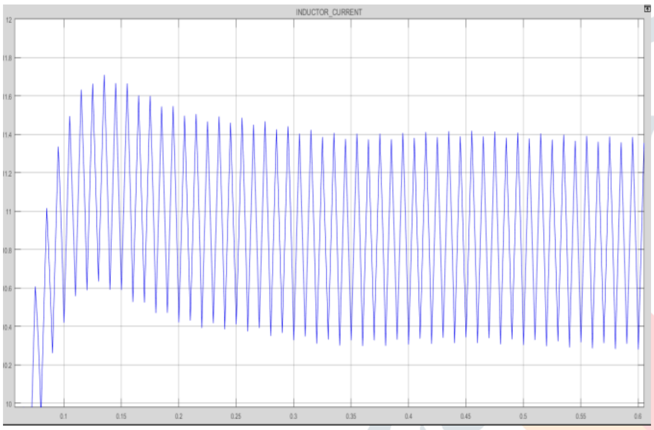


Fig: Phasor diagram of inverter voltage and grid voltage

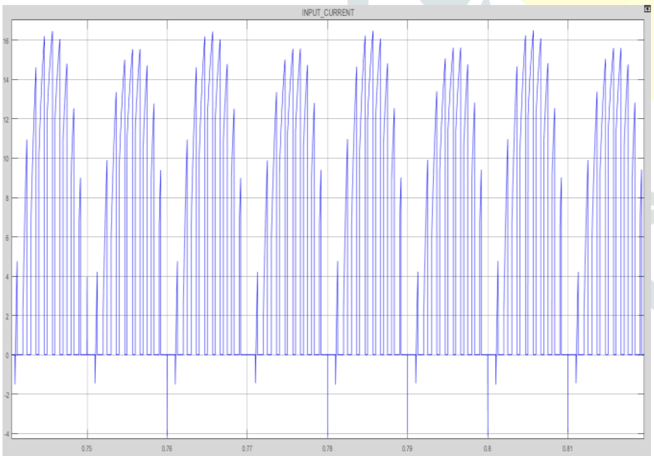


Fig: Frequency of grid and inverter supplies

TABLE SIMULATION PARAMETERS

Components	Parameters
Battery	366V, 8Ah
Inductance L	2.1 mH
Grid Voltage	240V
Grid Frequency	50Hz
Switching frequency	3780Hz
Solar Panel properties	
No of cells per module	60
Maximum power	249.86 watts
Open circuit voltage	37.6 v
Short circuit current	8.55 A
Voltage at maximum power point	31 v
Current at maximum power point	8.06 A

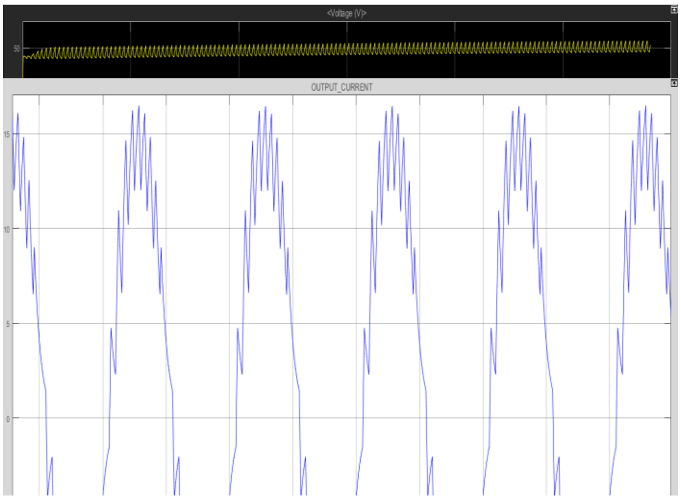


Fig: Inverter output current

2. BATTERY LOAD

The output from the PV panel becomes low when the solar irradiance is very low output power.the power is being supplied from the battery to the load. The inverter output voltage is shown.

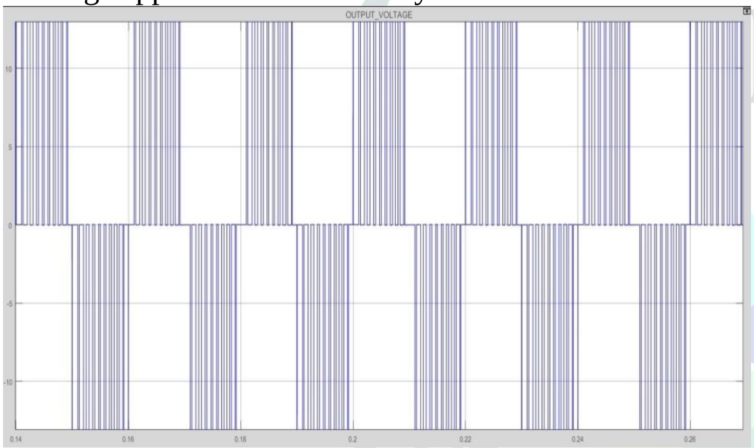


Fig: Inverter output voltage

3. PV BATTERY

The PV source is used to charge the battery and the charging voltage along with the state of charge is shown.

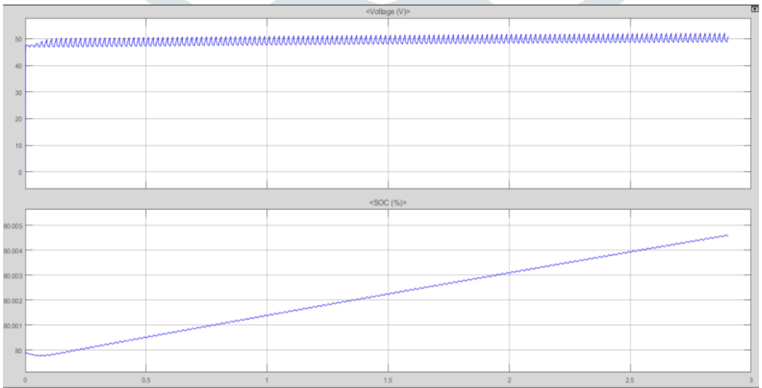
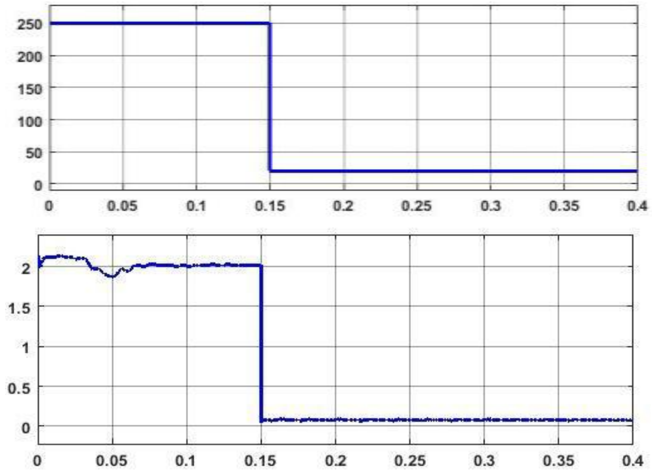


Fig: Battery charging by PV panel

4. PV BATTERY GRID

The solar power gets reduced when the solar irradiance becomes too low due to atmospheric conditions. The power to the load is provided by the PV and battery in this conditions. There is a change in solar radiation at 0.15 second. The solar panel current and power decreases are shown as the result.



(a)PV panel current (b)PV panel power (c)DC link voltage during change in irradiance when no battery supply

The DC link voltage is also decreasing. So that at 0.15 second, the battery supply is switchd in to provide power to load. The battery supply is maintaining the DC link voltage and inverter voltage constantly.

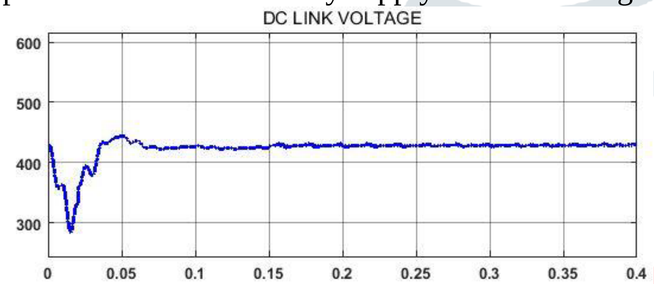


Fig: DC link voltage

An harmonic analysis was carried out for all mode of operation. The total harmonic distortion values are higher than the limits prescribed by IEEE standards, Since the reactive power control is not employed in control logic. The THD value of mode 1 where power is delivered from Pv TO GRID IS 33.13 When the battery supplies the power to load, the THD value is 62.31% as shown. The THD value is 33.19% when the power is being provided by both the PV and the battery. Thus for the PI control is being without the reactive power compensation , the harmonic distortion is not within the limits specified by the IEEE standards.

IV. CONCLUSION

A reconfigurable single phase inverter topology for PV- grid interconnection was discussed. It provides a simple and feasible method for connecting PV to grid by using a single conversion system to perform different modes such as PV to grid, battery to load, PV to battery and PV/battery to load. A single conversion stage reduces the cost and volume of the system. Simulation results are provided to demonstrate the working of inverter. The results confirm that the inverter is synchronized with grid. Harmonic analysis was carried out and THD values were obtained. It was found that harmonic distortion of a simple dq control without reactive power compensation is not within the limits. The harmonic distortion can be reduced by applying suitable reactive power control method. Other distributed energy sources can also be incorporated with the topology.

V. REFERENCES

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